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THE BRITISH ASSOCIATION.

TWENTY-FOUR years ago the British Association held a memorable meeting at Bath, for in the midst of it Livingstone came back from Central Africa and journeyed to the Queen of the West to tell of the wonders he had seen and the discoveries he had made. No such startling event is likely to occur during the meeting which opened on Wednesday with the delivery by Sir Frederick Bramwell of the very interesting address which we print with this. But there is little doubt that one more will be added to the many pleasant meetings which have been held, and the main object of the Association's meetings will be attained. The cause of science will be made popular, and the scientific workers will enjoy a well-earned recreation.

ADDRESS BY SIR FREDERICK BRAMWELL,
D.C.L., F.R.S., M.INST.C.E., PRESIDENT.

THE late Lord Iddesleigh delighted an audience, for a whole evening, by an address on "Nothing." Would that I had his talents, and could discourse to you as charmingly as he did to his audience, but I dare not try to talk about "Nothing." I do, however, propose, as one of the two sections of my address, to discourse to you on the importance of the "Next-to-nothing." The other section is far removed from this microscopic quantity, as it will embrace the "eulogy of the civil engineer," and will point out the value to science of his works.

I do not intend to follow any system in dealing with these two sections. I shall not even do as Mr. Dick, in "David Copperfield," did—have two papers, to one of which it was suggested he should confine his memorial and his observations as to King Charles's head. The result is, you will find, that the importance of the next-to-nothing, and the laudation of the civil engineer, will be mixed up in the most illogical and haphazard way throughout my address. I will leave to such of you as are of orderly minds the task of rearranging the subjects as you see fit, but I trust—arrangement or no arrangement—that by the time I have brought my address to a conclusion I shall have convinced you that there is no man who more thoroughly appreciates the high importance of the "next-to-nothing" than the civil engineer of the present day, the object of my eulogy this evening.

If I may be allowed to express the scheme of this address in modern musical language, I will say that the "next-to-nothing" "motive" will commonly usher in the "praise song" of the civil engineer; and it seems to me will do this very fitly, for in many cases it is by the patient and discriminating attention paid to the effect of the "next-to-nothing" that the civil engineer of the present day has achieved some of the labours of which I now wish to speak to you.

An association for the advancement of science is necessarily one of such broad scope in its objects, and is so thoroughly catholic as regards science, that the only possible way in which it can carry out those objects at all is to segregate its members into various subsidiary bodies, or sections, engaged on particular branches of science. Even when this division is resorted to, it is a hardy thing to say that every conceivable scientific subject can be dealt with by the eight sections of the British Association. Nevertheless, as we know, for 57 years the Association has carried on its labours under sections, and has earned the right to say that it has done good service to all branches of science.

Composed, as the Association is, of a union of separate sections, it is only right and according to the fitness of things that, as time goes on, your presidents should be selected, in some sort of rotation, from the various sections. This year it was felt, by the council and the members, that the time had once more arrived when Section G—the Mechanical Section—might put forward its claim to be represented in the presidency; the last time on which a purely engineering member filled the chair having been at Bristol in 1875, when that position was occupied by Sir John Hawkshaw. It is true that at Southampton, in 1883, our lamented friend, Sir William Siemens, was president, and it is also true that he was a most thorough engineer and representative of Section G;

but all who knew his great scientific attainments will probably agree that, on that occasion, it was rather the Physical Section A which was represented, than the Mechanical Section G.

I am aware it is said Section G does not contribute much to pure science by original research, but that it devotes itself more to the application of science. There may be some foundation for this assertion, but I cannot refrain from the observation, that when engineers, such as Siemens, Rankine, Sir William Thomson, Fairbairn, or Armstrong, make a scientific discovery, Section A says it is made not in the capacity of an engineer, and, therefore, does not appertain to Section G, but in the capacity of a physicist, and therefore appertains to Section A—an illustration of the danger of a man's filling two positions, of which the composite Prince-Bishop is the well-known type. But I am not careful to labour this point, or even to dispute that Section G does not do much for original research. I don't agree it is a fact, but, for the purposes of this evening, I will concede it to be so. But what then? This Association is for the "advancement of science"—the advancement be it remembered; and I wish to point out to you, and I trust I shall succeed in establishing, that for the advancement of science it is absolutely necessary there should be the application of science, and that, therefore, the section, which as much as any other (or, to state the fact more truly, which more than any other) in the Association applies science, is doing a very large share of the work of advancing science, and is fully entitled to be periodically represented in the presidency of the whole Association.

I trust also I shall prove to you that applications of science, and discoveries in pure science, act and re-act the one upon the other. I hope in this to carry the bulk of my audience with me, although there are some, I know, whose feelings, from a false notion of respect for science, would probably find vent in the "toast" which one has heard in another place—"this toast" being attributed to the pure scientist—"Here's to the latest scientific discovery: may it never do any good to anybody!"

To give an early illustration of this action and re-action, which I contend occurs: take the well-worn story of Galileo, Torricelli, and the pump maker. It is recorded that Galileo first, and his pupil Torricelli afterwards, were led to investigate the question of atmospheric pressure, by observing the failure of a pump to raise water by "suction," above a certain level. Perhaps you will say the pump maker was not applying science, but was working without science. I answer, he was unknowingly applying it, and it was from that which arose in this unconscious application that the mind of the pure scientist was led to investigate the subject, and thereupon to discover the primary fact, of the pressure of the atmosphere, and the subsidiary facts which attend thereon. It may appear to many of you that the question of the exercise of pressure by the atmosphere should have been so very obvious, but little merit ought to have accrued to the discoverer; and that the statement, once made, must have been accepted almost as a mere truism. This was, however, by no means the case. Sir Kenelm Digby, in his "Treatise on the Nature of Bodies," printed in 1658, disputes the proposition altogether, and says, in effect, he is quite sure, the failure of the pump to raise water was due to imperfect workmanship of some kind or description, and had nothing to do with the pressure of the air; and that there is no reason why a pump should not suck up water to any height. He cites the boy's sucker, which, when applied to a smooth stone, will lift it, and he says the reason why the stone follows the sucker is this. Each body must have some other body in contact with it. Now, the stone being in contact with the sucker, there is no reason why that contact should be broken up, for the mere purpose of substituting the contact of another body, such as the air. It seems pretty clear, therefore, that even to an acute and well-trained mind, such as that of Sir Kenelm Digby, it was by no means a truism, and to be forthwith accepted when once stated, that the rise of water on the "suction side" of a pump was due to atmospheric pressure. I hardly need point out that the pump maker should have been a member of "G." Galileo and Torricelli, led to reflect by what they saw, should have been members of "A" of the then "Association for the Advancement of Science."

But, passing away from the question of the value of the application of science of a date some two and a half centuries ago, let us come a little nearer to our own times.

Electricity—known in its simplest form to the Greeks by the results arising from the friction on amber, and named therefrom; afterwards produced from glass cylinder machines, or from plate machines; and produced a century ago by the "Influence" machine—remained, as did the discoveries of Volta and Galvani, the pursuit of but a few, and even the brilliant experiments of Davy did not suffice to give very great impetus to this branch of physical science.

Ronalds, in 1823, constructed an electric telegraph. In 1837 the first commercial use was made of the telegraph, and from that time electrical science received an impulse such as it had never before experienced. Further scientific facts were discovered; fresh applications were made of these discoveries. These fresh applications led to renewed vigour in research, and there was the action and re-action of which I have spoken. In the year 1871 the Society of Telegraph Engineers was established. In the year 1861 our own Association had appointed a committee to settle the question of electrical standards of resistance, which committee, with enlarged functions, continued its labours for twenty years; and of this committee I had the honour of being a member. The results of the labours of that committee endure (somewhat modified, it is true), and may be pointed to as one of the evi-

demonstrates the value of the work done by the British Association. Since Ronald's time, how vast are the advances which have been made in electrical communication of intelligence, by land lines, by submarine cables all over the world, and by the telephone! Few will be prepared to deny the statement, that pure electrical science has received an enormous impulse, and has been advanced by the commercial application of electricity to the foregoing, and to purposes of lighting. Since this latter application, scores, I may say hundreds, of acute minds have been devoted to electrical science, stimulated thereto by the possibilities and probabilities of this application.

In this country, no doubt, still more would have been done if the lighting of districts from a central source of electricity had not been, since 1832, practically forbidden by the Act passed in that year. This Act had in its title the facetious statement that it was "to facilitate electrical lighting"—although it is an Act which, even modified as it has been this year, is still a great discouragement of free enterprise, and a bar to progress. The other day a member of the House of Commons was saying to me: "I think it is very much to our discredit in England that we should have allowed ourselves to be outrun in the distribution of electric lighting to houses, by the inhabitants of the United States, and by those of other countries." Looking upon him as being one of the authors of the "facetious" Act, I thought it pertinent to quote the case of the French parricide, who, being asked what he has to say in mitigation of punishment, pleads, "Pity a poor orphan"—the parricide and the legislator being both of them authors of conditions of things which they affect to deplore. I will say no more on this subject, for I feel that it would not be right to take advantage of my position here to-night to urge Political Economy views, which should be reserved for Section F. I will merely, and as illustrative of my views of the value of the application of science to science itself, say there is no branch of physics pursued with more zeal and with more happy results than that of electricity, with its allies, and there is no branch of science towards which the public looks with greater hope of practical benefits—a hope that, I doubt not, will be strengthened after we have had the advantage of hearing one of the ablest followers of that science, Professor Ayrton, who, on Friday next, has been good enough to promise to discourse on "The Electrical Transmission of Power."

One of the subjects which, as much as (or probably more than) any other, occupies the attention of the engineer, and therefore of Section G, is that of (the so-called) prime movers, and I will say boldly that, since the introduction of printing by the use of movable type, nothing has done so much for civilisation as the development of these machines. Let us consider these prime movers—and, first, in the comparatively humble function of replacing that labour which might be performed by the muscular exertion of human beings, a function which at one time was looked upon by many kindly but short-sighted men as taking the bread out of the mouth of the labourer (as it was called), and as being therefore undesirable. I remember revisiting my old schoolmaster, and his saying to me, shaking his head:—"So you have gone the way I always feared you would, and are making things of iron and brass, to do the work of men's hands."

It must be agreed that all honest and useful labour is honourable, but when that labour can be carried out without the exercise of any intelligence, one cannot help feeling that the result is likely to be intellectually lowering. Thus it is a sorry thing to see unintelligent labour, even although that labour be useful. It is but one remove from unintelligent labour which is not useful; that kind of labour generally appointed (by means of the tread-wheel or the crank) as a punishment for crime. Consider even the honourable labour (for it is useful, and it is honest) of the man who earns his livelihood by turning the handle of a crane, and compare this with the labour of a smith, who, while probably developing more energy by the use of his muscles, than is developed by the man turning the crane-handle, exercises at the same time the powers of judgment, of eye, and of hand in a manner which I never see without my admiration being excited. I say that the introduction of prime movers as a mere substitute for unintelligent manual labour is in itself a great aid to civilisation and to the raising of humanity, by rendering it very difficult, if not impossible, for a human being to obtain a livelihood by unintelligent work—the work of the horse in the mill, or of the turnspit.

But there are prime movers and prime movers—those of small dimensions, and employed for purposes where animal power or human power might be substituted, and those which attain ends that by no conceivable possibility could be attained at all by the exertion of muscular power.

Compare a galley, a vessel propelled by oars, with the modern Atlantic liner; and first let us assume that prime movers are non-existent and that this vessel is to be propelled galley-fashion. Take her length as some 600 feet, and assume that place be found for as many as 400 oars on each side, each oar worked by three men, or 2,400 men; and allow that six men under these conditions could develop work equal to one horse-power: we should have 400 horse-power. Double the number of men, and we should have 800 horse-power, with 4,800 men at work, and at least the same number in reserve, if the journey is to be carried on continuously. Contrast the puny result thus obtained with the 19,500 horse-power given forth by a large prime mover of the present day, such a power requiring, on the above mode of calculation, 117,000 men at work and 117,000 in reserve; and these to be carried in a vessel less than 600 feet in length. Even if it were possible to carry this number of men in such a vessel, by no conceivable means could their power be utilised so as to impart to it a speed of twenty knots an hour.

This illustrates how a prime mover may not only be a mere substitute for muscular work, but may afford the means of attaining an end, that could not by any possibility be attained by muscular exertion, no matter what money was expended or what galley-slave suffering was inflicted.

Take again the case of a railway locomotive. From 400 to 600 horse-power developed in an implement which, even including its tender, does not occupy an area of more than fifty square yards, and that draws us at 60 miles an hour. Here, again, the prime mover succeeds in doing that which no expenditure of money or of life could enable us to obtain from muscular effort.

To what, and to whom, are these meritorious prime movers due? I answer: to the application of science, and to the labours of the civil engineer, using that term in its full and proper sense, as embracing all engineering other than military. I am, as you know, a civil engineer, and I desire to laud my profession and to magnify mine office; and I know of no better means of doing this than by quoting to you the definition of "civil engineering," given in the Charter of the Institution of Civil Engineers, namely, that it is "the art of directing the great sources of power in Nature for the use and convenience of man." These words are taken from a definition or description of engineering given by one of our earliest scientific writers on the subject, Thomas Tredgold, who commences that description by the words above-quoted, and who, having given various illustrations of the civil engineer's pursuits, introduces this pregnant sentence:—

"This is, however, only a brief sketch of the objects of civil engineering, the real extent to which it may be applied is limited only by the progress of science; its scope and utility will be increased with every discovery in philosophy, and its resources with every invention in mechanical or chemical art, since its bounds are unlimited, and equally so must be the researches of its professors."

"The art of directing the great sources of power in Nature for the use and convenience of man." Among all secular pursuits, can there be imagined one more vast in its scope, more beneficent, and therefore one more honourable, than this? There are those, I know—hundreds, thousands—who say that such pursuits are not to be named as on a par with those of literature; that there is nothing ennobling in them; nothing elevating; that they are of the earth, earthy; are mechanical, and are unintellectual, and that even the mere bookworm, who, content with storing his own mind, neither distributes those stores to others nor himself originates, is more worthily occupied than is the civil engineer.

I deny this altogether, and, while acknowledging, with gratitude, that, in literature, the masterpieces of master minds have afforded, and will afford, instruction, delight, and solace for all generations, so long as civilisation endures, I say that the pursuits of civil engineering are worthy of occupying the highest intelligence, and that they are elevating and ennobling in their character.

Remember the kindly words of Sir Thomas Browne, who said, when condemning the uncharitable conduct of the mere bookworm, "I make not, therefore, my head a grave, but a treasure of knowledge, and study not for mine own sake only, but for those who study not for themselves." The engineer of the present day finds that he must not make his "head a grave," but that, if he wishes to succeed, he must have, and must exercise, scientific knowledge; and he realises daily the truth that those who are to come after him must be trained in science, so that they may readily appreciate the full value of each scientific discovery as it is made. Thus the application of science by the engineer not only stimulates those who pursue science, but adds him to their number.

Holding, as I have said I do, the view that he who displaces unintelligent labour is doing good to mankind, I claim for the unknown engineer who, in Pontus, established the first water-wheel of which we have a record, and for the equally unknown engineer who first made use of wind for a motor, the title of pioneers in the raising of the dignity of labour, by compelling the change from the non-intelligent to the intelligent.

With respect to these motors—wind and water—we have two proverbs which discredit them: "Fickle as the wind," "Unstable as water."

Something more trustworthy was needed—something that we were sure of having under our hands at all times. As a result, Science was applied, and the "fire" engine, as it was first called, the "steam" engine, as it was re-named, a form of "heat" engine, as we now know it to be, was invented.

Think of the early days of the steam-engine—the pre-Watt days. The days of Papin, Savory, Newcomen, Smeaton! Great effects were produced, no doubt, as compared with no fire engine at all; effects so very marked as to extort from the French writer Belidor, the tribute of admiration he paid to the "fire" engine erected at the Farnes Colliery by English engineers. A similar engine worked the pumps in York Place (now the Adelphi) for the supply of water to portions of London. We have in his work one of the very clearest accounts, illustrated by the best engravings (absolute working drawings), of the engine which had excited his admiration. These drawings show the open-topped cylinder, with condensation taking place below the piston, but with the valves worked automatically.

It need hardly be said that, noteworthy as such a machine was, as compared with animal power, or with wind or water motors, it was of necessity a most wasteful instrument as regards fuel. It is difficult to conceive in these days how, for years, it could have been endured that at each stroke of the engine the chamber

that was to receive the steam at the next stroke was carefully cooled down beforehand by a water injection.

Watt, as we know, was the first to perceive, or, at all events, to cure, this fundamental error which existed prior to his time in the "fire" engine. To him we owe condensation in a separate vessel, the doing away with the open-topped cylinder, and the making the engine double-acting; the parallel motion; the governor; and the engine indicator, by which we have depicted for us the way in which the work is being performed within the cylinder. To Watt, also, we owe that great source of economic working—the knowledge of the expansive force of steam; and to his prescience we owe the steam jacket, without which expansion, beyond certain limits, is practically worthless. I have said "prescience"—foreknowledge—but I feel inclined to say that, in this case, prescience may be rendered "pre-science," for I think that Watt felt the utility of the steam jacket, without being able to say on what ground that utility was based.

I have already spoken in laudatory terms of Tredgold, as being one of the earliest of our scientific engineering writers, but, as regards the question of steam jacketing, Watt's prescience was better than Tredgold's science, for the latter condemns the steam jacket, as being a means whereby the cooling surfaces are enlarged, and whereby, therefore, the condensation is increased.

I think it is not too much to say, that engineers who, since Watt's days, have produced machines of such marvellous power—and, compared with the engines of Watt's days, of so great economy—have, so far as principles are concerned, gone upon those laid down by Watt. Details of the most necessary character—necessary to enable those principles to be carried out—have, indeed, been devised since the days of Watt. Although it is still a very sad confession to have to make, that the very best of our steam engines only utilises about one-sixth of the work which resides (if the term may be used) in the fuel that is consumed, it is, nevertheless, a satisfaction to know that great economical progress has been made, and that the 6 or 7 lbs. of fuel per horse-power per hour consumed by the very best engines of Watt's days, when working with the aid of condensation, is now brought down to about one-fourth of this consumption; and this in portable engines, for agricultural purposes, working without condensation—engines of small size, developing only 20 horse-power; in such engines the consumption has been reduced to as little as 1·85 lb. per brake horse-power per hour, equal to 1·65 lb. per indicated horse-power per hour, as was shown by the trials at the Royal Agricultural Society's meeting at Newcastle last year—trials in which I had the pleasure of participating.

In these trials Mr. William Anderson, one of the Vice-Presidents of Section G, and I were associated, and in making our report of the results we adopted the balance-sheet system, which I suggested and used so long ago as 1873 (see Vol. 53, pages 154 and 155, of the "Minutes of Proceedings of the Institution of Civil Engineers"), and to which I alluded in my address as President of G at Montreal.

I have told you that the engineer of the present day appreciates the value of the "next-to-nothings." There is an old housekeeping proverb that, if you take care of the farthings and the pence, the shillings and the pounds will take care of themselves. Without the balance sheet one knows that for the combustion of 1 lb. of coal the turning into steam of a given quantity of water at a given pressure is obtained. It is seen at once that the result is much below that which should be had, but to account for the deficiency is the difficulty. The balance sheet, dealing with the most minute sources of loss—the farthings and the pence of economic working—brings you face to face with these, and you find that improvement must be sought in paying attention to the "next-to-nothings."

Just one illustration. The balance sheet will enable you at a glance to answer this among many important questions. Has the fuel been properly burnt?—with neither too much air, nor too little.

At the Newcastle trials our knowledge as to whether we had the right amount of air for perfect combustion was got by an analysis of the waste gases, taken continuously throughout the whole number of hours' run of each engine, affording, therefore, a fair average. The analysis of any required portion of gases thus obtained was made in a quarter of an hour's time by the aid of the admirable apparatus invented by Mr. Stead, and, on the occasion to which I refer, manipulated by him. In one instance an excess of air had been supplied, causing a percentage of loss of 8·34. In the instance of another engine there was a deficiency of air, resulting in the production of carbonic oxide, involving a loss of 4 per cent. The various percentages of loss, of which each one seems somewhat unimportant, in the aggregate amounted to 28 per cent., and this with one of the best boilers. This is an admirable instance of the need of attention to apparently small things.

I have already said that we now know the steam engine is really a heat engine. At the York meeting of our Association I ventured to predict that, unless some substantive improvement were made in the steam engine (of which improvement, as yet, we have no notion), I believed its days, for small powers, were numbered, and that those who attended the centenary of the British Association in 1931 would see the present steam engines in museums, treated as things to be respected, and of antiquarian interest to the engineers of those days, such as are the open-topped steam cylinders of Newcomen and of Smeaton to ourselves. I must say I see no reason, after the seven years which have elapsed since the York meeting, to regret having made that prophecy, or to desire to withdraw it.

The working of heat engines, without the intervention of the

vapour of water, by the combustion of the gases arising from coal, or from coal and from water, is now not merely an established fact, but a recognised and undoubted, commercially economical, means of obtaining motive power. Such engines, developing from 1 to 40 horse-power, and worked by the ordinary gas supplied by the gas mains, are in most extensive use in printing works, hotels, clubs, theatres, and even in large private houses, for the working of dynamos to supply electric light. Such engines are also in use in factories, being sometimes driven by the gas obtained from "culm" and steam, and are giving forth a horse-power for, it is stated, as small a consumption as 1 lb. of fuel per hour.

It is hardly necessary to remind you—but let me do it—that, although the saving of half a pound of fuel per horse-power appears to be insignificant, when stated in that bald way, one realises that it is of the highest importance when that half-pound turns out to be 33 per cent. of the whole previous consumption of one of those economical engines to which I have referred.

The gas engine is no new thing. As long ago as 1807 a M. de Rivas proposed its use for driving a carriage on ordinary roads. For anything I know he may not have been the first proposer. It need hardly be said that in those days he had not illuminating gas to resort to, and he proposed to employ hydrogen. A few years later a writer in *Nicholson's Journal*, in an article on "Flying Machines," having given the correct statement that all that is needed to make a successful machine of this description is to find a sufficiently light motor, suggests that the direction in which this may be sought is the employment of illuminating gas, to operate by its explosion on the piston of an engine. The idea of the gas engine was revived, and formed the subject of a patent by Barnett in the year 1838. It is true this gentleman did not know very much about the subject, and that he suggested many things which, if carried out, would have resulted in the production of an engine which could not have worked; but he had an alternative proposition which would have worked.

Again, in the year 1861, the matter was revived by Lenoir, and in the year 1865, by Hugon, both French inventors. Their engines obtained some considerable amount of success and notoriety, and many of them were made and used; but in the majority of cases they were discarded as wasteful and uncertain. The Institution of Civil Engineers, for example, erected a Lenoir in the year 1868, to work the ventilating fan, but after a short time they were compelled to abandon it and to substitute an hydraulic engine.

At the present time, as I have said, gas engines are a great commercial success, and they have become so by the attention given to small things, in popular estimation—to important things, in fact, with which, however, I must not trouble you. Messrs. Crossley Brothers, who have done so much to make the gas engine the commercial success that it is, inform me that they are prosecuting improvements in the direction of attention to detail, from which they are obtaining greatly improved results.

But, looking at the wonderful petroleum industry, and at the multifarious products which are obtained from the crude material, is it too much to say that there is a future for motor engines, worked by the vapour of some of the more highly volatile of these products—true vapour—not a gas, but a condensable body, capable of being worked over and over again? Numbers of such engines, some of as much as 4 horse-power, made by Mr. Yarrow, are now running, and are apparently giving good results; certainly excellent results as regards the compactness and lightness of the machinery; for boat purposes they possess the great advantage of being rapidly under way. I have seen one go to work within two minutes of the striking of the match to light the burner.

Again, as we know, the vapour of this material has been used as a gas in gas engines, the motive power having been obtained by direct combustion.

Having regard to these considerations, was I wrong in predicting that the heat engine of the future will probably be one independent of the vapour of water? And, further, in these days of electrical advancement, is it too much to hope for the direct production of electricity from the combustion of fuel?

As the world has become familiar with prime movers, the desire for their employment has increased. Many a household could find useful occupation for a prime mover of $\frac{1}{2}$ or $\frac{1}{4}$ horse-power, working one or two hours a day; but the economical establishment of a steam engine is not possible until houses of very large dimensions are reached, where space exists for the engine, and where, having regard to the amount of work to be done, the incidental expenses can be borne. Where this cannot be, either the prime mover, with the advantages of its use, must be given up as a thing to be wished for, but not to be procured, or recourse must be had to some other contrivance—say to the laying on of power, in some form or another, from a central source.

I have already incidentally touched upon one mode of doing this, namely, the employment of illuminating gas, as the working agent in the gas engine; but there are various other modes, possessing their respective merits and demerits—all ingenious, all involving science in their application, and all more or less in practical use—such as the laying-on of special high-pressure water, as is now being extensively practised in London, in Hull, and elsewhere. Water at 700 lbs. pressure per inch is a most convenient mode of laying on a large amount of power, through comparatively small pipes. Like electricity, where, when a high electromotive force is used, a large amount of energy may be sent through a small conductor, so with water, under high pressure, the mains may be kept of reasonable diameters, without rendering them too small to transmit the power required through them.

Power is also transmitted by means of compressed air, an agent

which, on the score of its ability to ventilate, and of its cleanliness, has much to recommend it. On the other hand, it is an agent which, having regard to the probability of the deposition of moisture in the form of "snow," requires to be worked with judgment.

Again, there is an alternative mode for the conveyance of power by the exhaustion of air—a mode which has been in practical use for over sixty years.

We have also the curious system pursued at Schaffhausen, where quick-running ropes are driven by turbines, these being worked by the current of the river Rhine; and at New York, and in other cities of the United States, steam is laid on under the streets, so as to enable domestic steam engines to be worked, without the necessity of a boiler, a stoker, or a chimney, the steam affording also means of heating the house when needed.

Lastly, there is the system of transmitting power by electricity, to which I have already adverted. I was glad to learn, only the other day, that there was every hope of this power being applied to the working of an important subterranean tramway.

These distributions from central sources need, as a rule, statutory powers to enable the pipes or wires to be placed under the roads; and, following the deplorable example of the Electrical Facilities Act, it is now the habit of the enlightened corporation and the enterprising town clerk of most boroughs to say to capitalists who are willing to embark their capital in the plant for the distribution of power from a central source—for their own profit, no doubt, but also, no doubt, for the good of the community—"We will oppose you in Parliament, unless you will consent that, at the end of twenty-one years, we may acquire compulsorily your property, and may do so, if it turns out to be remunerative, without other payment than that for the mere buildings and plant at that time existing." This is the way English enterprise is met, and then English engineers are taunted, by Englishmen—often by the very men who have had a share in making this "boa-constrictor" of a "Facilities Act"—that their energy is not to be compared with that which is to be found in the United States and other countries. Again, however, I must remember that I am not addressing Section F.

There is one application of science, by engineers, which is of extreme beauty and interest, and that cannot be regarded with indifference by the agriculturists of this country. I allude to the heat-withdrawing engines (I should like to say, "cold producers," but I presume, if I did, I should be criticised), which are now so very extensively used for the importation of fresh meat, and for its storage when received here. It need hardly be said, that that which will keep cool and sweet the carcasses of sheep will equally well preserve milk and many other perishable articles of food. We have in these machines daily instances that, if you wish to make a ship's hold cold, you can do it by burning a certain quantity of coals—a paradox, if ever there was one.

In this climate of ours, where the summer has been said to consist of "three hot days and a thunderstorm," there is hardly need to make a provision for cooling our houses, although there is an undoubted need for making a provision to heat them. Nevertheless, those of us who have hot water heating arrangements for use in the winter would be very glad indeed if, without much trouble or expense, they could turn these about, so as to utilise them for cooling their houses in summer. Mr. Loftus Perkins, so well known for his labours in the use of very high-pressure steam (600 to 1,000 lbs. on the inch), and also so well known for those most useful high-pressure warming arrangements which, without disfiguring our houses by the passage of large pipes, keep them in a state of warmth and comfort throughout the winter, has lately taken up the mode of, I will say it, producing "cold" by the evaporation of ammonia, and, by improvements in detail, has succeeded in making an apparatus which, without engine or pumps, produces "cold" for some hours in succession, and requires, to put it in action, the preliminary combustion of only a few pounds of coke or a few feet of gas.

As I have said, our climate gives us but little need to provide or employ apparatus to cool our houses, but one can well imagine that the Anglo-Indian will be glad to give up his punkah for some more certain, and less draughty, mode of cooling.

I now desire to point out how, as the work of the engineer grows, his needs increase. New material, or better material of the old kind, has to be found to enable him to carry out these works of greater magnitude. At the beginning of this century, stone, brick, and timber were practically the only materials employed for that which I may call standing engineering work—i.e., buildings, bridges, aqueducts, and so on—while timber, cast iron, and wrought iron were for many years the only available materials for the framing and principal parts of moving machines and engines, with the occasional use of lead for the pipes and of copper for pipes and for boilers.

As regards the cast iron, little was known of the science involved (or that ought to be involved) in its manufacture. It was judged of by results. It was judged of largely by the eye. It was "white," it was "mottled," it was "grey." It was known to be "fit for refining," fit for "strong castings," or fit for castings in which great fluidity in the molten metal was judged to be of more importance than strength in the finished casting. With respect to wrought iron, it was judged of by its results also. It was judged of by the place of its manufacture—but when the works of the district were unknown, the iron, on being tested, was classed as "good fibrous," although some of the very best was "steel-like," or "bad," "hot-short," or "cold-short." A particular district would produce one kind of iron, another district

another kind of iron. The ore, the flux, and the fuel were all known to have influence, but to what extent was but little realised; and if there came in a new ore, or a new flux, it might well be that for months the turn-out of the works into which these novelties had been introduced would be prejudiced. Steel again—that luxury of the days of my youth—was judged by the eye. The wrought bars, made into "blister" by "cementation," were broken, examined, and grouped accordingly. Steel was known, no doubt, to be a compound of iron and carbon, but the importance of exactness in the percentage was but little understood, nor was it at all understood how the presence of comparatively small quantities of foreign matter might necessitate the variation of the proportions of carbon. The consequence was that anomalous results every now and then arose to confound the person who had used the steel, and falsifying the proverb "true as steel," steel became an object of distrust. Is it too much to say that Bessemer's great invention of steel made by the "converter," and that Siemens's invention of the open-hearth process, reacted on pure science, and set scientific men to investigate the laws which regulate the union of metals and of metalloids?—and that the labours of these scientific men have improved the manufacture, so that steel is now thoroughly and entirely trusted? By its aid engineering works are accomplished which, without that aid, would have been simply impossible. The Forth Bridge, the big gun, the compound armour of the ironclad with its steel face, the projectile to pierce that steel face—all equally depend upon the "truth" of steel as much as does the barely visible hair spring of the chronometer, which enables the longitude of the ship in which it is carried to be ascertained. Now, what makes the difference between trustworthy and untrustworthy steel for each particular purpose? Something which, until our better sense comes to our aid, we are inclined to look upon as ridiculously insignificant—a "next-to-nothing." Setting extraneous ingredients aside, and considering only the union of iron and carbon, the question whether there shall be added or deducted one-tenth of 1 per cent. (pardon my clumsy way of using the decimal system) of carbon is a matter of great importance in the resulting quality of the steel. This is a striking practical instance of how apparently insignificant things may be of the highest importance. The variation of this fraction of a percentage may render your boiler steel untrustworthy, may make the difference between safety in a gun and danger in a gun, and may render your armour-piercing projectile unable to pierce even the thinnest wrought-iron armour.

While thus brought incidentally to the subject of guns, let me derive from it another instance of the value of small things. I have in my hand a piece of steel ribbon. It is probable that only those who are near to me can see it. Its dimensions are one-fourth by one-sixteenth of an English inch, equal to an area of one sixty-fourth of a square inch. This mode of stating the dimensions I use for the information of the ladies. To make it intelligible to my scientific friends, I must tell them that it is approximately $\cdot 00637$ of a metre, by approximately $\cdot 00169$ of a metre, and that its sectional area is $\cdot 0000101283$ (also approximately) of a square metre. This insignificant (and speaking in reference to the greater number of my audience), practically invisible piece of material—that I can bend with my hand, and even tie into knots—is, nevertheless, not to be despised. By it one reinforces the massive and important-looking A tube of a 9·2-inch gun, so that from that tube can be projected with safety a projectile weighing 380 lbs. at a velocity, when leaving the muzzle, of between one-third and one-half of a mile in a second, and competent to traverse nearly 12½ miles before it touches the ground. It may be said, "What is the use of being able to fire a projectile to a distance which commonly is invisible (from some obstacle or another) to the person directing the gun?" I will suggest to you a use. Imagine a gun of this kind placed by some enemy who, unfortunately, had invaded us, and had reached Richmond. He has the range table for his gun; he, of course, is provided with our Ordnance maps, and he lays and elevates the gun at Richmond, with the object of striking, say, the Royal Exchange. Suppose he does not succeed in his exact aim. The projectile goes 100 yards to one side or to the other; or it falls 350 yards short, or passes 250 yards over; and it would be "bad shooting" indeed, in these days, if nearly every projectile which was fired did not fall somewhere within an area such as this. In this suggested parallelogram of 100,000 square yards, or some 30 acres, there is some rather valuable property; and the transactions which are carried on are not unimportant. It seems to me that business would not be conducted with that calmness and coolness which are necessary for success, if, say every five minutes, a 380 pound shell fell within this area, vomiting fire, and scattering its walls in hundreds of pieces, with terrific violence, in all directions. Do not suppose I am saying that similar effects cannot be obtained from a gun where wire is not employed. They can be. But my point is, that they can also be obtained by the aid of the insignificant thing which I am holding up at this moment—this piece of steel ribbon, which looks more suitable for the framework of an umbrella.

I have already spoken to you, when considering steel as a mere alloy of iron and carbon, as to the value of even a fraction of 1 per cent. of the latter; but we know that in actual practice steel almost always contains other ingredients. One of the most prominent of these is manganese. It had for years been used, in quantities varying from a fraction of 1 per cent. up to 2½ per cent., with advantage as regards ductility, and as regards its ability to withstand forging. A further increase was found not to augment the advantage: a still further increase was found to

diminish it: and here the manufacturer stopped, and, so far as I know, the pure scientist stopped, on the very reasonable ground that the point of increased benefit appeared to have been well ascertained, and that there could be no advantage in pursuing an investigation which appeared only to result in decadence. But this is another instance of how the application of science reacts on the interests of pure science itself. One of our steel manufacturers, Mr. Hadfield, determined to pursue this apparently barren subject, and in doing so discovered this fact—that, while with the addition of manganese in excess of the limit before stated, and up to as much as 7 per cent., deterioration continued, after this latter percentage was passed improvement again set in.

Again, the effects of the addition of even the very smallest percentages of aluminium upon the steel with which it may be alloyed are very striking and very peculiar, giving to the steel alloy thus produced a very much greater hardness, and enabling it to take a much brighter and more silver-like polish. Further, the one-twentieth part of 1 per cent. of aluminium, when added to molten wrought iron, will reduce the fusing point of the whole mass some 500 degrees, and will render it extremely fluid, and thus enable wrought iron (or what are commercially known as "mittis"—castings of the most intricate character) to be produced.

No one has worked more assiduously at the question of the effect of the presence of minute quantities, even traces, of alloys with metals than Prof. Roberts-Austen, and he appears, by his experiments, to be discovering a general law, governing the effect produced by the mixture of particular metals, so that, in future, it is to be hoped, when an alloy is for the first time to be attempted, it will be possible to predict with reasonable certainty what the result will be, instead of that result remaining to be discovered by experiment.

I have just, incidentally, mentioned aluminium. May I say that we engineers look forward, with much interest, to all processes tending to bring this metal, or its alloys, within possible commercial use?

One more instance of the effect of impurities in metals. The engineer engaged in electrical matters is compelled, in the course of his daily work, frequently to realise the importance of the "next-to-nothing." One striking instance of this is afforded by the influence which an extremely minute percentage of impurity has on the electrical conductivity of copper wire: this conductivity being in some cases reduced by as much as 50 per cent., in consequence of the admixture of that which, under other circumstances, would be looked upon as insignificant.

Reverting to the question of big guns. According to the present mode of manufacture, after we have rough-bored and turned the "A" tube (and perhaps I ought to have mentioned that by the "A" tube is meant the main piece of the gun, the innermost layer, if I may so call it, that portion which is the full length of the gun, and upon which the remainder of the gun is built up)—after, as I have said, we have rough-bored and turned this "A" tube, we heat it to a temperature lying between certain specified limits, but actually determined by the behaviour of samples previously taken, and then suddenly immerse it perpendicularly into a well some 80 feet deep, full of oil, the oil in this well being kept in a state of change by the running into it, at the bottom, of cold oil conveyed by a pipe proceeding from an elevated oil tank. In this way the steel is oil-hardened, with the result of increasing its ultimate tensile strength, and also with the result of raising its so-called elastic limit. In performing this operation it is almost certain that injurious internal strains will be set up: strains tending to produce self-rupture of the material. Experiments have been carried out in England by Captain Andrew Noble, and by General Maitland of the Royal Gun Factory, by General Kalakoutsky in Russia, and also in the United States, to gauge what is the value, as represented by dimensions, of these strains, and we find that they have to be recorded in the most minute fractions of an inch, and yet, if the steel be of too "high" a quality (as it is technically called), or if there has been any want of uniformity in the oil-hardening process, these strains, unless got rid of or ameliorated by annealing, may, as I have said, result in the self-rupture of the steel.

I have spoken of the getting rid of these strains by annealing, a process requiring to be conducted with great care, so as not to prejudice the effects of the oil-hardening. But take the case of a hardened steel projectile, hardened so that it will penetrate the steel face of compound armour. In that case annealing cannot be resorted to, for the extreme hardness of the projectile must not be in the least impaired. The internal strains in these projectiles are so very grave, that for months after they are made there is no security that they will not spontaneously fracture. I have here the point of an 8-inch projectile, which projectile weighs 210 lbs., this with others was received from the makers as long ago as March of this year, and remained an apparently perfect and sound projectile until about the middle of August—some five months after delivery—and, of course, a somewhat longer time since manufacture—and between August 6th and 8th this piece which I hold in my hand, measuring 3½ inches by 3½ inches, spontaneously flew off from the rest of the projectile, and has done so upon a surface of separation which, whether having regard to its beautiful regularity, or to the conclusions to be drawn from it as to the nature of the strains existing, is of the very highest scientific interest. Many other cases of self-rupture of similar projectiles have been recorded.

Another instance of the effect of the "next-to-nothing" in the hardening and tempering or annealing of steel. As we know, the iron and the carbon (leaving other matters out of consideration) are there. The carbon is (even in tool-steel) a very small pro-

portion of the whole. The steel may be bent, and will retain the form given to it. You heat it and plunge it in cold water; you attempt to bend it and it breaks; but if, after the plunging in cold water, you temper it by carefully reheating it, you may bring it to the condition fit either for the cutting-tool for metal, or for the cutting-tool for wood, or for the watch-spring; and these important variations of condition which are thus obtained depend upon the "next-to-nothing" in the temperature to which it is reheated, and therefore in the nature of the resulting combination of the ingredients of which the steel is composed.

Some admirable experiments were carried out on this subject by the Institution of Mechanical Engineers, with the assistance of one of our Vice-Presidents, Sir Frederick Abel, and the subject has also been dealt with by an eminent Russian writer.

There is, to my mind, another and very striking popular instance (if I may use the phrase) of the importance of attention to detail—that is, to the "next-to-nothing." Consider the bicycles and tricycles of the present day—machines which afford the means of healthful exercise to thousands, and which will, probably within a very short time, prove of the very greatest possible use for military purposes. The perfection to which these machines have been brought is almost entirely due to strict attention to detail; in the selection of the material of which the machines are made; in the application of pure science (in its strictest sense) to the form and to the proportioning of the parts, and also in the arrangement of these various parts in relation the one to the other. The result is that the greatest possible strength is afforded with only the least possible weight, and that friction in working has been reduced to a minimum. All of us who remember the hobby-horse of former years, and who contrast that machine with the bicycle or tricycle of the present day, realise how thoroughly satisfactory is the result of this attention to detail—this appreciation of the "next-to-nothing."

Let me give you another illustration of the importance of small things, drawn from gunnery practice.

At first sight one would be tempted to say that the density of the air on the underside of a shot must, notwithstanding its motion of descent, be so nearly the same as that of the air upon the upper side as to cause the difference to be unworthy of consideration, but we know that the projectiles from rifled guns tend to travel sideways as they pass through the air, and that the direction of their motion, whether to the right or to the left, depends on the "hand" of the rifling. We know, also, that the friction against liquid or against gaseous bodies varies with the densities of these bodies, and it is believed that, minute as is the difference in density to which I have referred, it is sufficient to determine the lateral movement of the projectile. This lateral tendency must be allowed for, in these days of long ranges, in the sighting and laying of guns, if we desire accuracy of aim, at those distances at which it is to be expected our naval engagements will have to be commenced, and perhaps concluded. We can no longer afford to treat the subject as Nelson is said to have treated it, in one of his letters to the Secretary of the Admiralty, who had requested that an invention for laying guns more accurately should be tried. Nelson said he would be glad to try the invention, but that, as his mode of fighting consisted in placing his ship close alongside that of the enemy, he did not think the invention, even if it were successful, would be of much use to him.

While upon the question of guns, I am tempted to remark upon that which is by no means a small thing (for it is no less than the rotation of the earth), which in long-distance firing may demand attention, and that to an extent little suspected by the civilian.

Place the gun north and south, say in the latitude of London, and fire a 12-mile round such as I have mentioned, and it will be found that, assuming the shot were passing through a vacuum, a lateral allowance of more than 200 feet must be made to compensate for the different velocity of the circumference of the earth at 12 miles north or south of the place where the gun was fired, as compared with the velocity of the circumference of the earth at that place itself—the time of flight being in round numbers one minute.

At the risk of exciting a smile, I am about to assert that engineering has even its poetical side. I will ask you to consider with me whether there may not be true poetry in the feelings of the engineer who solves the problem such as this: Consider this rock, never visible above the surface of the tide, but making its presence known by the waves which rise around it; it has been the cause of destruction to many a noble vessel which had completed, in safety, its thousands of leagues of journey, and was, within a few score miles of port; then dashed to pieces upon it? Here is this rock. On it build a lighthouse. Lay your foundations through the water, in the midst of the turmoil of the sea; make your preparations; appear to be attaining success, and find the elements are against you and that the whole of your preliminary works are ruined or destroyed in one night; but again commence, and then go on and go on until at last you conquer; your works rise above ordinary tide-level; then upon these sure foundations, obtained it may be after years of toil, erect a fair shaft, graceful as a palm and sturdy as an oak; surmount it with a light, itself the produce of the highest application of science; direct that light by the built-up lens, again involving the highest application of science; apply mechanism, so arranged that the lighthouse shall from minute to minute reveal to the anxious mariner its exact name and its position on the coast. When you have done all this, will you not be entitled to say to yourself, "It is I who have for ever rendered innocuous this rock which has been hitherto a dread source of peril?" Is

there feeling, do you think, of a poetical nature excited in the breast of the engineer who has successfully grappled with a problem such as this?

Another instance: the mouth of a broad river, or, more properly speaking, the inlet of the sea, has to be crossed at such a level as not to impede the passage of the largest ships. Except in one or two places the depth is profound, so that multiple foundations for supporting a bridge become commercially impossible, and the solution of the problem must be found by making, high in the air, a flight of span previously deemed unattainable. Is there no poetry here? Again, although the results do not strike the eye in the same manner, is there nothing of poetry in the work, that has to be thought out and achieved, when a wide river or an ocean channel has to be crossed by a subterranean passage? Works of great magnitude of this character have been performed with success, and to the benefit of those for whose use they were intended. One of the greatest and most noble of such works, encouraged, in years gone by, by the Governments of our country and of France, has lately fallen into disfavour with an unreasoning public, who have not taken the pains to ascertain the true state of the case.

Surely it will be agreed that the promotion of ready intercourse and communication between nations constitute the very best, and most satisfactory guarantee for the preservation of peace; when the peoples of two countries come to know each other intimately, and when they, therefore, enter into closer business relations, they are less liable to be led away by panic or by anger, and they hesitate to go to war the one with the other. It is in the interests of both that questions of difference which may arise between them should be amicably settled, and having an intimate knowledge of each other, they are less liable to misunderstand, and the mode of determination of their differences is more readily arranged. Remember, the means of ready intercourse and of communication, and the means of easy travel, are all due to the application of science by the engineer. Is not therefore his profession a beneficent one?

Further, do you not think poetical feeling will be excited in the breast of that engineer who will in the near future solve the problem (and it certainly will be solved when a sufficiently light motor is obtained) of travelling in the air—whether this solution be effected by enabling the self-suspended balloon to be propelled and directed, or perhaps, better still, by enabling not only the propulsion to be effected and the direction to be controlled, but by enabling the suspension in the air itself to be attained by mechanical means?

Take other functions of the civil engineer—functions which, after all, are of the most important character, for they contribute directly to the prevention of disease, and thereby not only prolong life, but do that which is probably more important—afford to the population a healthier life while lived.

In one town, about which I have full means of knowing, the report has just been made that in the year following the completion of a comprehensive system of sewerage, the deaths from zymotic diseases had fallen from a total of 740 per annum to a total of 372—practically one half. Has the engineer no inward satisfaction who knows such results as these have accrued from his work?

Again, consider the magnitude and completeness of the water supply of a large town, especially a town that has to depend upon the storing-up of rain water: the provision which takes into account, not merely the variation of the different seasons of the year, but the variation of one year from another; that, having collated all the stored-up information, determines what must be the magnitude of the reservoirs to allow for at least three consecutive dry years, such as may happen; and that finds the sites where these huge reservoirs may be safely built.

All these—and many other illustrations which I could put before you if time allowed—appear to me to afford conclusive evidence that, whether it be in the erection of the lighthouse on the lonely rock at sea; whether it be in the crossing of rivers or seas, or arms of seas, by bridges or by tunnels; whether it be the cleansing of our towns from that which is foul; whether it be the supply of pure water to every dwelling, or the distribution of light or of motive power; or whether it be the production of the mighty ocean steamer, or in the spanning of valleys, the piercing of mountains, and affording the firm, secure road for the express train; or whether it be the encircling of the world with telegraphs—the work of the civil engineer is not of the earth earthy, is not mechanical to the exclusion of science, is not unintellectual; but is of a most beneficent nature, is consistent with true poetical feeling, and is worthy of the highest order of intellect.

ADDRESS TO THE MECHANICAL SCIENCE SECTION OF THE BRITISH ASSOCIATION.

By W. H. PREECE, F.R.S., M.Inst. C.E., &c.,
President of the Section.

"CANST thou bring down the lightnings from heaven that they may say unto thee, Here we are?" were pregnant words addressed to Job unknown centuries ago. They express the first recorded idea in history of the potentiality of electricity to minister to the wants of mankind. From Job to Franklin is a long swing in the pendulum of time. It was not until that American philosopher brought down atmospheric electricity by his kite-string in 1747, and showed that we could lead it where we willed, that we were able to answer the question addressed to the ancient patriarch. Nearly another century elapsed before this mysterious

power of Nature was fairly conquered. It has been during this generation, and during the life of the British Association, that electricity has been usefully employed; and it is because I have taken a subordinate position in inaugurating nearly all of its practical applications, that I venture to make the developments of them the text of my address to this section.

People are singularly callous in matters affecting their own personal safety; they will not believe in mysteries, and they ridicule or condemn that which they do not understand. The Church itself set its face against Franklin's "impious" theories, and he was laughed to scorn by Europe's scientific sons; and even now, though commissions composed of the ablest men of the land have sat and reported on Franklin's work in England, France, and nearly every civilised nation, the public generally remains not only ignorant of the use of lightning conductors, but absolutely indifferent to their erection, and, if erected, certainly careless of their proper maintenance. I found in a church not very far from here the conductor led into a tombstone, and in a neighbouring cathedral the conductor only a few inches in the ground, so that I could draw it out with my hand. Although I called the attention of the proper authorities to the absolute danger of the state of affairs, they remained in the same condition for years.

Wren's beautiful steeple in Fleet Street, St. Bride's, was well-nigh destroyed by lightning in 1764. A lightning rod was fixed, but so imperfectly that it was again struck. In July last (1887) it was damaged because the conductor had been neglected, and had lost its efficiency.

As long as points remain points, as long as conductors remain conductors, as long as the rods make proper connection with the earth, lightning protectors will protect; but if points are allowed to be fused, or to corrode away; as long as bad joints or faulty connections are allowed to remain; as long as bad earths, or no earths exist, so long will protectors cease to protect; and they will become absolute sources of danger. Lightning conductors, if properly erected, duly maintained, and periodically inspected, are an absolute source of safety; but if erected by the village blacksmith, maintained by the economical churchwarden, and never inspected at all, a loud report will some day be heard, and the beautiful steeple will convert the churchyard into a new geological formation.

We have not yet acquired that mental confidence in the accuracy of the laws that guide our procedure in protecting buildings from the effects of atmospheric electrical discharges which characterises most of the practical applications of electricity. Some of our cherished principles have only very recently received a rough shaking from the lips of Prof. Oliver Lodge, F.R.S., who, however, has supported his brilliant experiments by rather fanciful speculation, and whose revolutionary conclusions are scarcely the logical deduction from his novel premises. The whole subject is going to be thoroughly discussed at this meeting.

We are now obtaining much valuable information about the nature of lightning from photography. We learn that it does not, as a rule, take zigzag course conventionally used to represent a flash on canvas. Its course is much more erratic and sinuous, its construction more complicated, and pictures have been obtained of dark flashes whose *raison d'être* has not yet been satisfactorily accounted for. The network of telegraph wires all over the country is peculiarly subject to the effects of atmospheric electricity, but we have completely mastered the vagaries of lightning discharges in our apparatus and cables. Accidents are now very few and far between.

The art of transmitting intelligence to a distance beyond the reach of the ear and the eye, by the instantaneous effects of electricity, had been the dream of the philosopher for nearly a century, when in 1837 it was rendered a practical success by the commercial and far-sighted energy of Cooke, and the scientific knowledge and inventive genius of Wheatstone. The metallic arc of Galvani (1790) and the developments of Volta (1796) had been so far improved that currents could be generated of any strength, the law of Ohm (1828) had shown how they could be transmitted to any distances, the deflection of the magnetic needle by Oersted in 1819, and the formation of an electro-magnet by Ampère and Sturgeon, and the attraction of its armature had indicated how those currents could be rendered visible as well as audible.

Cooke and Wheatstone in 1837 utilised the deflection of the needle to the right and the left to form an alphabet. Morse used the attraction of the armature of an electro-magnet to raise a metal style to impress or emboss moving paper with visible dots and dashes. Steinheil imprinted dots in ink on the different sides of a line on paper, and also struck two bells of different sound to affect the ear. Bréguet reproduced in miniature the actual movements of the semaphore then so much in use in France; while others rendered practical the favourite idea of moving an indicator around a dial, on which the alphabet and the numerals were printed, and causing it to dwell against the symbol to be read—the A, B, C instrument of Wheatstone in England, and of Siemens in Germany. Wheatstone conceived the notion of printing the actual letters of the alphabet in bold Roman type on paper—a plan which was made a perfect success by Hughes in 1854.

At the present moment the needle system of Cooke and Wheatstone, as well as the A, B, C dial telegraph, are very largely used in England on our railways, and in our smaller post offices. The Morse recorder and the Hughes type-printer are universally used on the Continent; while in America the dot and dash alphabet of Morse is impressed on the consciousness through the ear by the sound of the moving armature striking against the stops that limit its motion. In our larger and busier offices the Morse sounder and the bell system, as perfected by Bright are very largely used,

while the press of this country is supplied with news which is recorded on paper by ink dots and dashes at a speed that is almost fabulous.

Sir William Thomson's mirror—the most delicate form of the needle system—where the vibratory motions of an imponderable ray of light convey words to the reader, and his recorder, where the wavy motion of a line of ink spirted on paper by the frictionless repulsion of electricity performs the same function, are exclusively employed on our long submarine cables.

Bakewell in 1848 showed how it was possible to reproduce facsimiles of hand-writing and of drawing at a distance, and in 1879 E. A. Cowper reproduced one's own handwriting, the moving pen at one station so controlling the currents flowing on the line wire that they caused a similar pen to make similar motions at the other distant station. Neither of these plans, the former beautifully developed by Caselli and d'Arlincourt, and the latter improved by Robertson and Elisha Gray, have yet reached the practical stage.

The perfection of telegraphy has been attained by that chief marvel of this electrical age—the speaking telephone of Graham Bell. The reproduction of the human voice at a distance, confined only by geographical limits, seems to have reached the confines of human ingenuity; and though wild enthusiasts have dreamt of reproducing objects abroad visible to the naked eye at home, no one at the present moment can say that such a thing is possible, while in face of the wonders that have been done no one dare say that it is impossible.

The commercial business of telegraphy, when our thoughts and wishes, orders and wants, could be transmitted for money, was inaugurated in this country by the establishment of the Electric Telegraph Company in 1846, and until 1870 it remained in the hands of private enterprise, when it was purchased by the Government, and placed under the sole control of the Postmaster-General. It has been the fashion to decry the terms of purchase of the various undertakings then at work by those who have not understood the question, and by those who, being politically opposed to the Government in power at the time, saw all their acts, not only through a glass darkly, but through a reversing lens. A business producing £550,000 per annum was bought at twenty years' purchase, and that business has now increased to £2,000,000 per annum. 6,000,000 messages per annum have increased to 52,000,000.

Every post office has been made a telegraph office, every village of any size has its wire; messages which used to cost 12s. 6d. are now sent for 6d.; a tariff which was vexatious from its unfair variation is now uniform over the United Kingdom, and no one can justly complain of error or delay in the transmission of their messages. Silly complaints are sometimes inserted in the press, of errors which the most elementary knowledge of the Morse alphabet would detect, and little credit is given to the fact that the most perfect telegraph is subject to strange disturbances from terrestrial and atmospheric causes which admit sources of error beyond the control of the telegraphist. A flash of lightning in America may cause an extra dot in Europe, and war may become war. An earthquake in Japan may send a dash through France, and life would become wry. A wild goose flying against a telegraph wire might drive it into momentary contact with another wire, and night might become night. Everyone should know his Morse alphabet, and people should learn how to write. Nineteenth of the errors made are due to the execrable calligraphy of the present day. As a matter of fact, in ninety-nine cases out of a hundred, the telegraphist delivers to the editor of a newspaper "copy" far more accurate than the first proof of his own leader submitted by the printer. The quantity of news transmitted is enormous, an average of 1,588,270 words are delivered per day. The recent convention in Chicago, when the Republican party of the United States nominated their candidate for the presidency, created so much business that every American paper has chronicled this big thing as unique. 500,000 words were sent on one night; but we in England, when Mr. Gladstone introduced his celebrated Home Rule Bill on April 8th, 1886, sent from the Central Telegraph Office in London 1,500,000 words.

The growth of business has led to vast improvement in the carrying capacity of the wires. Cooke and Wheatstone required five wires for their first needle instrument to work at the rate of four words per minute. One wire can now convey six messages at ten times the speed. The first Morse apparatus could work at about five words a minute; we now transmit news at the rate of 600 words a minute. In 1875 it was thought wonderful to transmit messages to Ireland at 80 words a minute. When I was recently in Belfast I timed messages coming at the rate of 461 words a minute. Duplex working—that is, two messages travelling on the same wire at the same time in opposite directions, the invention of Gintl, of Vienna—is now the normal mode of working; Edison's quadruplex is common; and the Delany system of multiplex working is gradually being introduced, by which six messages are indiscriminately sent in either direction. The telegraphic system of England has been brought to the highest pitch of perfection. We have neither neglected the inventions of other countries, nor have we been chary of exercising inventive skill ourselves, and we have received our full meed of that reward which is always freely bestowed on a British Government official, neglect and abuse. All parts of the civilised world are now united by submarine cables. The *Times* every morning has despatches from every quarter of the globe, giving the news of the previous day. 110,000 miles of cable have been laid by British ships, and nearly £40,000,000 of British capital has been expended by private enterprise in com-

pleting this grand undertaking. A fleet of 37 ships is maintained in various oceans to lay new cables and to repair breaks and faults as they occur—faults that arise, among other causes, from chafing on coral reefs, ships' anchors, the onslaught of insects, and earthquakes. The two cables connecting Australia and Java were recently simultaneously broken by an earthquake.

The politician, unmindful of the works of the engineer, is apt to apply to the credit of his own proceedings the growing prosperity of the world. The engineer, however, feels that steam and electricity in his hands have done more to economise labour, to cheapen life, to increase wealth, to promote international friendship, to alleviate suffering, to ward off war, to encourage peace, than all the legislation and all the verbosity of the politician.

The railways of this country are entirely dependent for the conduct of their traffic on the telegraph, and the security of their passengers is mainly due to the working of the block system. A railway, say between London and Bath, is broken up into certain short sections, and only one train is allowed on one section at one time. The presence, motion and departure of trains is announced and controlled by electric signals, and the out-door signals are governed by these electric signals. There are few more interesting places to visit than a well-equipped signal box on one of our main railways. The signalman is able to survey the lines all around and about him by aid of his electric signals; he can talk by telegraph or by telephone to his neighbours and his station master; he learns of the motion of the trains he is marshalling by the different sounds of electric bells; he controls his out-door signals by the deflection of needles, or the movement of miniature semaphores; he learns the true working of his distant signals by their electrical repetition; machinery governs and looks every motion he makes, so that he cannot make a mistake. The safety of railway travelling is indicated by the fact that while in the five years ending 1878 thirty-five people were killed annually from causes beyond their own control, in the five years ending 1887 the average has been reduced to sixteen. One person is killed in 35,000,000 journeys made by train. Wherever we are dependent on human agency we are subject to human error, and a serious accident very recently at Hampton Wick has shown how the most perfect machinery may be rendered valueless to protect life when perversity, thoughtlessness, or criminality enter as factors into the case.

At the meeting of the Association in Plymouth in 1877, I was able for the first time in this country to show the telephone at work. Since then its use has advanced with giant strides. There are probably a million instruments at work now throughout the civilised world. Its development has been regularly chronicled at our meetings. As far as the receiving part of the apparatus is concerned, it remains precisely the same as that which I brought over from America in 1877; but the transmitter, ever since the discovery of the microphone by Hughes in 1878, has been entirely remodelled. Edison's carbon transmitter was a great step in advance; but the modern transmitters of Moseley, Berliner, D'Arsonval, De Jongh, leave little to be desired. The disturbances due to induction have been entirely eliminated, and the laws regulating the distance to which speech is possible are so well known, that the specification of the circuit required to connect the Land's End with John O'Grat's by telephone is a simple question of calculation. A circuit has been erected between Paris and Marville, 600 miles apart, with two copper wires of 64 gauge, weighing 540 lbs. per mile, and conversation is easily maintained between those important cities at the cost of three francs for three minutes. One scarcely knows which fact is the more astounding—the distance at which the human voice can be reproduced, or the ridiculously simple apparatus that performs the reproduction. But more marvellous than either is the extreme sensitiveness of the instrument itself, for the energy contained in one heat unit (gramme-water-degree) would, according to Pellat, maintain a continuous sound for 10,000 years.

The influence which electric currents exert on neighbouring wires extends to enormous distances, and communication between trains and ships in motion, between armies inside and outside besieged cities, between islands and the mainland, has become possible without the aid of wires at all, by the induction which is exerted through space itself. On the Lehigh Valley Railway, in the United States, such a system of telegraphing without wires is in actual daily use.

The conduct of telephonic business in England is still in the hands of those who hold the patents, and who maintain a most rigid monopoly. These patents have only a short period to run, and when they expire we may expect to find that England will not occupy the very retired position she holds now as a telephone country. Stockholm has more subscribers than London; there are 15,000 subscribers in and about New York, while the number in London is only 4,851.

Electric lighting has become popular, not alone from the beauty of the light itself, but from its great hygienic qualities in maintaining the purity and coolness of the air we breathe. The electric light need not be more brilliant than gas, but it must be more healthy. It need not be cooler than a wax candle, but it must be brighter, steadier, and more pleasant to the eye. In fact, it can be rendered the most perfect artificial illuminant at our disposal, for it can illumine a room without being seen directly by the eye; it can be made absolutely steady and uniform without irritating the retina; it does not poison the air by carbonic acid and carbonic oxide, or dirty the decorations by depositing unconsumed carbon; it does not destroy books or articles of virtue and art by forming water which absorbs sulphur acids; and it does not unnecessarily heat the room.

In our Central Savings Bank in London it has been found, after two years' experience of electric lighting, that the average amount of absences from illness has been diminished by about two days a year for each person on the staff. This is equivalent to a gain to the service of the time of about eight clerks in that department alone. Taking the cost at the "overtime" rate only, this would mean a saving in salaries of about £840 a year. The cost of the installation of the electric light was £3,349, and the annual cost of working £700 per annum—say, a total annual cost of £1,084. The cost of the gas consumed for lighting purposes was about £700 a year, so that on the whole there was a direct saving of something like £366 a year to the Government, besides the material advantage of the better work of the staff resulting from the improved atmospheric conditions under which their work is done.

The production of light by any means implies the consumption of energy, and this can be measured in watts, or at the rate at which this energy is consumed. A watt is $\frac{1}{746}$ part of a horse-power. It is a very convenient and sensible unit of power, and will in time replace the meaningless horse-power.

One candle light maintained by tallow		absorbs	watts.
"	wax ...	"	94
"	sperm ...	"	86
"	mineral oil ...	"	80
"	vegetable oil ...	"	67
"	coal gas ...	"	68
"	cannel gas ...	"	48
"	electricity (glow) ...	"	3
"	electricity (arc) ...	"	55

The relative heat generation of these illuminants may be estimated from these figures.

Though the electric light was discovered by Davy in 1810, it was not until 1844 that it was introduced into our scientific laboratories by Foucault; it was not until 1878 that Jablockhoff and Brush showed how to light up our streets effectually and practically; it was not until 1881 that Edison and Swan showed how our homes could be illuminated softly and perfectly. Unpreparedness for such a revolution produced a perfect panic among gas proprietors; inexperience in the use of powerful electric currents resulted in frequent failure and danger; speculation in financial bubbles transferred much gold from the pockets of the weak to the coffers of the unscrupulous; hasty legislation in 1882 restricted the operations of the cautious and the wise; and the prejudice arising from all these causes has, perhaps fortunately, delayed the general introduction of electricity; but now legislation has been improved, experience has been gained, confidence is being restored, and in this beautiful town of Bath 50 streets are about to be lighted, and we see everywhere around and about us in our English homes the pure glow lamp replacing filthy gas and stinking oil. The economical distribution of the electric current over large areas is annually receiving a fresh impetus. The expensive systems defined in the Act of Parliament of 1882 have entirely disappeared. Hopkinson in England and Edison in America showed how a third wire reduced the weight of copper needed by 66 per cent. Gaulard and Gibbs in 1882 showed how the conversion of alternate currents of high electromotive force to currents of low electromotive force by simple induction coils would enable a mere telegraph wire to convey sufficient electricity to light a distant neighbourhood economically and efficiently. Lane-Fox in 1879 showed how the same thing could be done by secondary batteries; and Planté, Faure, Sellen, and Parker have done much to prove how batteries can be made to solve the problem of storage; while King and Edmunds have shown how the distribution by secondary batteries can be done as economically as by secondary generators. The Grosvenor Gallery Company in London have proved the practicability of the secondary generator principle by nightly supplying 24,000 glow lamps scattered over a very wide area of London. The glow lamp of Edison, which in 1881 required 5 watts per candle, has been so far improved that it now consumes but 2½ watts per candle. The dynamo, which in the same year weighed 50,000 lbs., absorbed 160 horse-power, and cost £4,000 for 1,000 lamps, now weighs 14,000 lbs., absorbs 110 horse-power, and costs £250 for the same production of external energy; in other words, its commercial output has been increased nearly six times, while its prime cost has been diminished eight times.

The steam engine has received equal attention. The economy of the electric light when steam is used depends almost entirely on the consumption of coal. With slow speed low pressure engines one kilowatt (1,000 watts, 1½ horse-power) may consume 12 lbs. of coal per hour; in high speed high pressure triple expansion engines it need not consume more than 1 lb. of coal per hour. Willans and Robinson have actually delivered from a dynamo one kilowatt by the consumption of 2 lbs. of coal per hour, or by the condensation of 20 lbs. of steam.

There is a great tendency to use small economical direct-acting engines in place of large expensive engines, which waste power in counterbalancing and belts. Between the energy developed in the furnace in the form of heat, and that distributed in our rooms in the form of light, there have been too many points of waste in the intermediate operations. These have now been eliminated or reduced. Electricity can now be produced by steam at 3d. per kilowatt per hour. The kilowatt hour is the Board of Trade unit as defined by the Act of 1882, for which the consumer of electric energy has to pay. Its production by gas engines costs 6d. per kilowatt hour, while by primary batteries it costs 3s. per kilowatt hour. The Grosvenor Gallery Company supply currents at 7½d. per kilowatt hour; a 20 candle-power lamp consuming 3 watts per

candle, and burning 1,200 hours per annum, expends 82,000 watt hours or 82 kilowatt hours, and it costs, at 7½d. per unit, 60s. per annum. If the electricity be produced on the premises, as is the case in the Post Office, in the House of Commons, and in many large places, it would cost 20s. 6d. per annum. I have found from a general average under the same circumstances, and for the same light in the General Post Office in London, that an electric glow lamp costs 23s. and a gas lamp 18s. per annum. The actual cost of the production of one candle light per annum of 1,000 hours is as follows:—

	s.	d.
Sperm candles ...	8	6
Gas (London) ...	1	3
Oil (petroleum) ...	0	8
Electricity, glow ...	0	9
" arc ...	0	14

The greatest development of the electric light has taken place on board ship. Our Admiralty have been foremost in this work. All our warships are gradually receiving their equipment. Our ocean-going passenger ships are also now so illuminated, and perhaps it is here that the comfort, security, and true blessedness of the electric light is experienced.

Railway trains are also being rapidly fitted up. The express trains to Brighton for a long time been so lighted, and now several northern railways, notably the Midland, are following suit. Our rocky coasts and prominent landfalls are also having their lighthouses fitted with brilliant arc lamps, the last being St. Katherine's Point on the Isle of Wight, where 60,000 candles throw their bright beams over the English Channel, causing many an anxious mariner to proceed on his way rejoicing.

Fontaine showed in Vienna, in 1873, that a dynamo was reversible—that is, if rotated by the energy of a moving machine, it would produce electric currents; or, if rotated by electric currents, it would move machinery. An electric current is one form of energy. If we have at one place the energy of falling water, we can, by means of a turbine and a dynamo, convert a certain portion of the energy of this falling water into an electric current. We transmit this current through proper conductors to any other place we like, and we can again, by means of a motor, convert the energy of the current into mechanical energy to do work by moving machinery, drawing tramcars, or in any other way. We can in this way transmit and utilise 50 per cent. of the energy of the falling water wherever we like. The waste forces of nature are thus within our reach. The waterfalls of Wales may be utilised in London; the torrents of the Highlands may work the tramways of Edinburgh; the wasted horse-power of Niagara may light up New York. The falls of Bushmills actually do work the tramway from Portrush to the Giant's Causeway, and those of Beasbrook the line from Newry to Beasbrook.

The practicability of the transmission of energy by currents is assured, and the economy of doing this is a mere matter of calculation. It is a question of the relative cost of the transmission of fuel in bulk, or of the transmission of energy by wire. Coal can be delivered in London for 12s. per ton. The mere cost of the upkeep of a wire between Wales and London to deliver the same amount of energy would exceed this sum tenfold. For long distances the transmission of energy is at present out of the question. There can be no doubt, however, that for many purposes within limited areas the transmission of energy by electricity would be very economical and effective. Pumps are worked in the mines of the Forest of Dean, cranes are moved in the works of Easton and Anderson at Erith, lifts are raised in banks in London; water is pumped up from wells to cisterns in the house of Sir Francis Truscott, near East Grinstead; ventilation is effected and temperature lowered in collieries; goods, minerals, and fuel can be transmitted by telpherage.

The transmission of power by electricity is thus within the range of practice. It can be distributed during the day by the same mains which supply currents for light by night. Small industries, such as printing, watch-making, tailoring, boot-making, can be cheaply supplied with power. It is thus brought into direct competition with the distribution of power by steam as in America, or by air-pressure as in Paris, or by high-pressure water as in London; and the relative advantages and economies of each system are simple questions of calculation. When that evil day arrives that our supply of natural fuel ceases, then we may look to electricity to bring to our aid the waste energies of nature—the heat of the sun, the tidal wave of the ocean, the flowing river, the roaring falls, and the raging storm.

There is a mode of transport which is likely to create a revolution in the method of working tramways. A tramcar carries a set of accumulators which supplies a current to work a motor geared to a pair of wheels of the car. The weight, price, day's work, and life of the accumulator is curiously the same as the weight, price, day's work, and life of horseflesh; but the cost of maintenance, the liability to accident, and the chances of failure are much less. Although very great improvements in batteries have been made, and they are now really practical things, sufficient experience in tramcar working has not yet been obtained to say that we have reached the proper accumulator. Nor have we yet acquired the best motor and mode of gearing; but very active experiments are being carried out in various countries, and nothing can prevent their ultimate success.

The property, which the electric current possesses, of doing work upon the chemical constitution of bodies so as to break up certain liquid compounds into their constituent parts, and marshal these disunited molecules in regular order according to a definite

law upon the surfaces of metals in contact with the liquid where the current enters and exists, has led to immense industries in electro-metallurgy and electro-plating. The extent of this industry may be gathered from the fact that there are 173 electro-platers in Sheffield and 99 in Birmingham. The term electro-metallurgy was originally applied to the electro-deposition of a thin layer of one metal on another; but this is now known as electro-plating.

In 1839 Jacobi in St. Petersburg and Spencer in Liverpool laid the foundations of all we know of these interesting arts. Copper was deposited by them so as to obtain exact reproductions of coins, medals, and engraved plates. The first patents in this country and in France were taken out by Messrs. Elkington, of Birmingham, who still occupy the foremost position in the country.

The fine metals, gold and silver, are deposited in thin layers on coarser metals, such as German silver, in immense quantities. Christofle, of Paris, deposits annually six tons of silver upon articles of use and of art, and if the surfaces so electro-plated were spread out continuously they would cover 140 acres.

The whole of the copper plates used in Southampton for the production of our splendid ordnance survey maps are deposited by copper on matrices taken from the original engraved plates, which are thus never injured or worn, while the copies may be multiplied at pleasure and renewed at any time.

Nickel-plating, by which the readily oxidisable metals like iron are coated with a thin layer of the more durable material nickel, is becoming a great industry; the trappings of harness, the exposed parts of machinery, the fittings of cycles and carriages, and innumerable articles of daily use are being rendered not only more durable but more beautiful.

The electro-deposition of iron, as devised by Jacobi and Klein, in the hands of Professor Roberts-Austen, F.R.S., is giving very interesting results. The dies for the coins which were struck at our Mint on the occasion of the Jubilee of the Queen, were modelled in plaster, reproduced in intaglio by the electro-deposition of copper, and on these copper moulds hard excellent iron in layers of nearly $\frac{1}{16}$ th of an inch was deposited.

The exact processes of measurement, which have led to such vast improvement in our telegraphic systems, have scarcely yet penetrated into this field of electrical industry, and little is known at present of the exact relations of current and electromotive force with respect to surfaces of contact, rate of deposit, and resistance of liquids. Captain Sankey, R.E., of the Ordnance Survey Department has done some useful work in this direction.

The extraction of metals from their ores by deposition has received wide application in the case of copper. In 1871 Elkington proposed to precipitate copper electrolytically from the fused sulphide of copper and iron known to the copper smelter as "regulus." Thin copper plates were arranged to receive the deposited copper while the foreign metals, including gold and silver, fell to the bottom of the solution, the process being specially applicable, it was supposed, to regulus containing small quantities of the precious metals.

The electrical purification of copper from impure "blister copper" or "blade copper" has also made great progress, and special dynamos are now made which will, with an expenditure of 100 horse-power, precipitate 18 tons of copper per week. The impure metal is made to form the anode in a bath of sulphate of copper, the metal being deposited in the pure form on a thin copper cathode.

It was not very long ago considered very economical to absorb '85 horse-power in depositing one pound of copper per hour, but now the same work can be done with '3 horse-power. Mr. Parker, of Wolverhampton, has done good work in this direction, and his dynamos in Messrs. Bolton's works have revolutionised this process of purification.

Both at Swansea and Widnes immense quantities of copper, in spite of the restrictive operations of the copper syndicate, are being produced by electro-deposition. Copper steam pipes for boilers are now being built up of great firmness, fine texture, and considerable strength by Mr. Elmore at Cockermouth, by electro-deposition on a rotating mandril in a tank of sulphate of copper. By this process one ton of copper requires only a little more than one ton of coal to raise the requisite steam to complete the operation.

It has been shown that the electrolytic separation of silver from gold by similar methods is perfectly practicable. The value of the material to be dealt with may be gathered from the fact, communicated to the "Gold and Silver Commission" now sitting, that nearly 90,000,000 ounces of silver are annually produced, and the greater portion of this amount contains sufficient gold to render refining remunerative. Although the old acid process of "parting" gold and silver remains practically undisturbed, there seems no reason to doubt that in the future electricity will render us good service in this direction as it has already in the purification of copper.

There is not much actual progress to report in the extraction of gold from its ores by electrical agency. The conversion of gold into chloride of gold by the direct, or indirect, action of chlorine is employed on a very large scale in [Grass Valley] California and elsewhere. This fact has led to well-directed efforts to obtain by electrolytic action, chlorine which should attack finely divided gold suspended (with the crushed ore) in the solution from which the chlorine was generated, the gold, so converted into soluble chloride, then being deposited on a cathode. The process would seem to be hopeful, but is not as yet a serious rival to the ordinary chlorination method.

In the amalgamation of gold ores much is expected from the

possibility of keeping clean, by the aid of hydrogen set free by the electric current, the surfaces of amalgamated plates.

It is well known that the late Sir W. Siemens considered that the electric arc might render good service in the fusion of metals with high melting points, and he actually succeeded in melting 96 ounces of platinum in 10 minutes with his electrical furnace. The experiments were interrupted by his untimely death, but in the hands of Messrs. Cowles the electric arc is produced by 5,000 amperes and 500 horse-power is being employed on a very large scale for the isolation of aluminium (from corundum), which is immediately alloyed (*in situ*) with copper or iron, in the presence of which it is separated.

The heating power of large currents has been used by John Thomson in the United States, and by Bernardo in Russia, to weld metals, and it is said to weld steel without affecting its hardness. It has even been proposed to weld together in one continuous metallic mass the rails of our railways, so as to dispense entirely with joints.

The production of chlorine for bleaching and of iodine for pharmaceutical purposes, the economical production of oxygen, are also processes now dependent on the electrolytic effect of the electric current.

It is almost impossible to enumerate the various general purposes to which electricity is applied to minister to our wants, and to add to our comforts. Every one appreciates the silent efficiency of the trembling electric bell, while all will sooner or later derive comfort from the perennially self-winding electric clock. Correct mean time is distributed throughout the length and breadth of the land by currents derived from Greenwich Observatory. Warehouses and shops are fitted with automatic contact pieces, which, on any undue increase of temperature due to fire, create an alarm in the nearest fire station; and at the corner of most streets a post is found with a face of glass, which on being broken, enables the passer-by or the watchful and active policeman to call a fire engine to the exact spot of danger. Our sewers are likely to find in its active chemical agency a power to neutralise offensive gases, and to purify poisonous and dangerous fluids. The germs of disease are attacked and destroyed in their very lairs. The physician and the surgeon trust to it to alleviate pain, to cure disease, to effect organic changes beyond the reach of drugs. The photographer finds in the brilliant rays of the arc lamp a miniature sun which enables him to pursue his lucrative business at night, or during the dark and dismal hours of a black November fog of London.

We learn from the instructive and interesting advertising columns of our newspapers that "electricity is life," and we may perhaps read in the more historical portion of the same paper that by a recent decision of the New York Parliament, "electricity is death." It is proposed to replace hanging by the more painless and sudden application of a powerful electrical charge; but those who have assisted at this hasty legislation would have done well to have assured themselves of the practical efficacy of the proposed process. I have seen the difficulty of killing even a rabbit with the most powerful induction coil ever made, and I know those who escaped and recovered from the stroke of a lightning discharge.

The fact that the energy of a current of electricity, either when it flashes across an air space, or when it is forced through high resistance, assumes the form of heat of very high temperature led early to its employment for firing charges of gunpowder; and for many civil, military, and naval purposes it has become an invaluable and essential agent. Wrecks like that of the *Royal George* at Spithead were blown up and destroyed; the faces of cliffs and quarries are thrown down; the galleries of mines and tunnels are excavated; obstructions to navigation like the famous Hell Gate, near New York, have been removed; time guns to distribute correct time are fired by currents from Greenwich at 1 p.m. In the operations of war, both for attack and defence, submarine mining has become the most important branch of the profession of a soldier and a sailor. Big guns, whether singly or in broadside, are fired, and torpedoes, when an enemy's ship unwittingly is placed over them, are exploded by currents of electricity.

An immense amount of research has been devoted to design the best form of fuse, and the best form of generator of electricity to use to explode them. Gun tubes for firing consist of a short piece of very fine wire embedded in some easily fusible compound, while the best form of fuse is that known as the Abel fuse, which is composed of a small, compact mass of copper phosphide, copper sulphide, and potassium chlorate. The practice in the use of generators is very various. Some, like the Austrians, lean to the high tension effects of static electricity; others prefer magneto machines; others use the dynamo; while we in England cling with much fondness to the trustworthy battery. Since the electric light has also become such a valuable adjunct to war purposes, it is probable that secondary batteries will become of immense service. The strong inductive effects of atmospheric electricity are a source of great danger. Many accidental explosions of fuses have occurred. An experimental cable with a fuse at one end was laid below low-water mark along the banks of the Thames at Woolwich. The fuse was exploded during a heavy thunderstorm. The knowledge of the causes of a danger is a sure means for the production of its removal, or of its reduction to a minimum. Low tension fuses and metallic circuits reduce the evils of lightning, but have not removed them. Should war unhappily break out again in Europe, submarine mining will play a very serious part, and, paradoxical as it may appear—as has been suggested by the French ambassador, M. Waddington—its very destructiveness may ultimately prove it to be a powerful element of peace.

It seems incredible that, having utilised this great power of nature to such a wide and general extent, we should be still in

state of mental fog as to the answer to be given to the simple question—What is Electricity? The engineer and the physicist are completely at variance on this point. The engineer regards electricity, like heat, light, and sound, as a definite form of energy, something that he can generate and destroy, something that he can play with and utilise, something that he can measure and apply. The physicist—at least some physicists, for it is difficult to find any two physicists that completely agree with each other—regard electricity as a peculiar form of matter permeating all space as well as all substances together with the luminiferous ether which it permeates like a jelly or a sponge. Conductors, according to this theory, are holes or pipes in this jelly, and electrical generators are pumps that transfer this hypothetical matter from one place to another. Other physicists, following Edlund, regard the ether and electricity as identical, and some, the disciples of Helmholtz, consider it as an integral constituent of nature, each molecule of matter having its own definite charge, which determines its attraction and its repulsion. All attempts to revive the Franklinian, or material theory of electricity, have, however, to be so loaded with assumptions, and so weighted with contradictions, that they completely fail to remove electricity from the region of the mysterious. It is already extremely difficult to conceive the existence of the ether itself as an infinitely thin, highly elastic medium, filling all space employed only as the vehicle of those undulatory motions that give us light and radiant heat. The material theory of electricity requires us to add to this another incomprehensible medium embedded or entangled in this ether, which is not a medium for motion, but which is itself moved. The practical man, with his eye and his mind trained by the stern realities of daily experience, on a scale vast compared with that of the little world of the laboratory, revolts from such wild hypotheses, such unnecessary and inconceivable conceptions, such a travesty of the beautiful simplicity of nature.

He has a clear conception of electricity as something which has a distinct objective existence, which he can manufacture and sell, and something which the unphilosophic and ordinary member of society can buy and use. The physicist asserts dogmatically: "Electricity may possibly be a form of matter—it is not a form of energy." The engineer says distinctly: "Electricity is a form of energy—it is not a form of matter; it obeys the two great developments of the present generation—the mechanical theory of heat and the doctrine of the conservation of energy." There must be some cause for this strange difference of views. It is clear that the physicist and the engineer do not apply the term electricity to the same thing. The engineer's electricity is a real form of energy; the speculative philosopher's electricity is a mere vague subjective unreality which is only a mere factor of energy and is not energy itself. This factor, like force, gravity, life, must, at any rate for the present, remain unknowable. It is not known what force is; neither do we know what is matter or gravity. The metaphysician is even doubtful as regards time and space. Our knowledge of these things commences with a definition. The human mind is so unimpressionable, or language is so poor, that writers often cannot agree even on a definition. The definition of energy is capacity for doing work. We practical men are quite content to start from this fiducial line, and to affirm that our electricity is a something which has a capacity for doing work; it is a peculiar form of energy. The physicist may speculate as much as he pleases on the other side of this line. He may take the factors of energy, and mentally play with them to his heart's content; but he must not rob the engineer of his term *electricity*. It is a pity that we cannot settle our difference by changing the term. Physicists might leave the term *electricity* to the form of energy, which is an objective reality, and which the ordinary mortal understands; while engineers would be quite content if speculative physicists and enthusiastic mathematicians would call their subjective unreality, their imaginary electrical matter, by some other term. If it be necessary to mentally create some imaginary matter to fulfil the assumptions and abstractions of their mathematical realisations, let them call it *coulombism* or *electron*, and not appropriate the engineer's generic and comprehensive term *electricity*. The engineer finds the motions of existing matter and of the ether quite sufficient to meet all his requirements, and to account for all those phenomena which are called electrical.

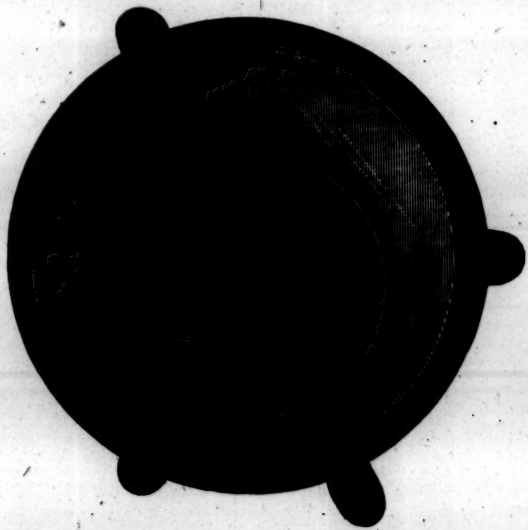
It seems paradoxical to assert that two unrealities can form a reality, or that two subjective ideas can become an objective one; but it must be remembered that in all electrical phenomena that which makes them real and objective is derived from without. The motion that renders an electrical phenomena evident is imparted to it from some other form of energy. The doctrine of the conservation of energy asserts that energy is never destroyed, it is only transformed—work must be done to render it evident. No single electrical effect can be added which is not the result of work done, and is not the equivalent of energy absorbed. The engineer's notion of work—something done against resistance; and of power—the rate at which this change of condition is effected—are the keystones to the conception of the character of those great sources of power in nature whose direction to the uses and convenience of man is the immediate profession of those who generally assemble together in Section G of the British Association to discuss the "practical application of the most important principles of natural philosophy which has, in a considerable degree, realised the anticipations of Bacon and changed the aspect and state of affairs in the whole world."

I cannot pretend to have given a survey of all the practical applications of electricity. I have but briefly indicated the present area covered by the new and rapidly growing industry.

Five million people upon the globe are now dependent on the electric current for their daily bread. Scarcely a week passes without some fresh practical application of its principles, and we seem to be only on the shore of that sea of economy and beneficence which expands with every new discovery of the properties of electricity, and spreads already beyond the mental grasp of any one single worker.

PROBERT'S SINGLE-POLE SWITCH.

THE illustration shows the switch in "closed circuit" position. To switch "on," the left-hand segment is driven into the jaws of a stout clip by moving the handle through about one-sixth part of a circle, and when thrust home it is securely locked by an appropriate catch on the surface of a flat spring which forms the base of the clip. By depressing the button above the clip the segment is liberated, and instantly flies back with the handle to its position of rest, under the tension of a strong coiled spring. This spring is composed of several copper ribbands, having one end rigidly attached to the central fixed pillar and the other end fastened to the segment; hence the act of closing the circuit winds up the spring. A flat metallic arm, working on the pillar, carries the segment and its appurtenances. Friction is thereby minimised, and the conductive capacity considerably increased.



The switch itself is surrounded by a brass band and covered by a clear glass plate, the whole being mounted on marble backed by a slate base. It will, therefore, be evident that while the essential parts are thoroughly protected from dust and damp, and the possibility of firing combustible matter effectually prevented, they are in full view through the glass plate.

The drawing was taken from a 100-ampere switch; but any desired current can be provided for. By multiplying the number of clips and segments, and suitably increasing their sectional area, very large currents can be safely controlled.

We understand that Mr. Probert has patented double-pole and reversing switches, small switches for single lamps, combined switch and safety fuse chamber, and other combination instruments. We hope to illustrate these as time and space permit.

An Electric Drill.—An electric drill weighing 100 pounds, that makes a hole 3 feet deep in hard anthracite in 30 seconds, and one 6 feet deep in one and a half minutes, is the latest thing in electric drilling machines. It is designed by Mr. W. M. Schlesinger, and made by the Union Electric Company of Philadelphia.

A SYNTHETIC STUDY OF DYNAMO
MACHINES.

(Continued from page 197.)

II.—LAWS OF INDUCED E.M.F.

8. *The Magnetic Field.*—We have seen that a magnetised needle takes up for every position in the vicinity of a magnet a particular axial direction. We have also seen that iron filings, when sprinkled on a piece of cardboard lying over a magnet, arrange themselves in lines curving from pole to pole. These filings becoming magnetised by induction, set their longer dimensions in line so that they all join on to each other, something like the links of a chain, and to the chains or lines of filings thus formed has been given the name *lines of force*. The experiments with the exploring needle and with the iron filings demonstrate that force is exerted in the vicinity of the magnet, and indicate the direction in which the force acts. The filings have, in fact, mapped out for us the direction of the force at every part of the magnetic field. But force has magnitude as well as direction, and up to the present we have said nothing of the magnitude of magnetic forces. We have proved that induced currents are the result of movement in a magnetic field when the motion is such as to add or subtract lines of force. But when so speaking the lines referred to have been a mere mental image of the chains of filings stretching between the poles of the magnet after both filings and cardboard have been removed.

Now if we are to calculate the E.M.F. induced by the movement of a conductor in a particular space, we must have this space very clearly described. If we are to make any statement by which the E.M.F. is expressed in terms of "lines of force," we must assign to each line of force some definite value, and furthermore, we must know how many lines of force are concerned in producing the effect. The iron filings experiment is most useful as an introduction to our study, but we require to know something more than the direction of the force, in order to calculate the induced E.M.F. We are now proceeding from the concrete to the abstract, and our object is to map out the field of force in such a way that its character, as revealed by experimental results, shall be completely described. In mechanics, forces are represented in magnitude and direction by lines, in order that their resolution may be achieved without difficulty. Geographers have drawn lines of latitude and longitude on the earth's surface, because it is convenient to describe, with reference to them, the several facts with which they deal. Electricians map out the magnetic field by lines drawn in a particular way, because the laws of induction can be completely expressed by reference to such lines.

Force is exerted everywhere in the magnetic field, and it is an easy matter, as we have seen, to exhibit its direction at every point by lines drawn from pole to pole. But how shall we map out the space that the lines shall represent both the direction and magnitude of the force? The mathematician here comes to our aid, and specifies the conditions which have to be fulfilled, in order that the space for the purpose of calculation may be completely defined. The magnitude of the force exerted in any particular locality shall be represented by the closeness of the lines in that locality, and the number of lines drawn shall be such that those passing through each square centimetre of a section at right angles to their direction, shall be numerically equal to the force which would be exerted in dynes on a pole of unit strength at that point. Accordingly as the lines are densely or sparsely packed, we say the field is strong or weak.

In passing, we must define the *dyne* and the *unit pole*; but when we have done this we will dismiss them from our minds as far as the present series of articles is concerned. In the absolute system forces are measured by the velocity generated in unit time on a free body of unit mass. In scientific measurement the units chosen are for distance the centimetre, for mass the

gramme, and for time the second. The unit of velocity is a rate of one centimetre per second, and in this the Centimetre-Gramme-Second—written shortly C.G.S.—system, the unit of force is that force which, acting for one second on a free body having a mass of 1 gramme, will generate in it a velocity of 1 centimetre per second. This unit of force is called the *dyne*.

It is convenient to define the pole of unit strength in terms of the dyne. We have observed that the opposite poles of two magnets attract each other while the similar poles repel, and the force of attraction or repulsion can be measured, of course, in any units we please. If for some little distance the lines of force may be considered as radiating uniformly from the pole (fig. 21),

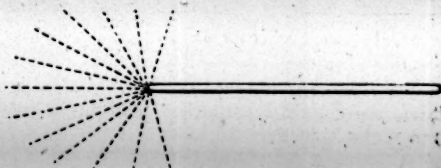


FIG. 21.

a condition only approximately fulfilled in practice, it is quite obvious that the density of the lines, or number passing through each square centimetre of section, is inversely as the square of the distance from the pole. If two poles of opposite sign be brought near each other, the attraction between them is proportional to the strength of the one multiplied into the strength of the other and inversely proportional to the square of their distance apart. If m_1 and m_2 are their respective strengths, and d their distance apart, the attraction if their poles are opposite, or repulsion, if alike, may be expressed as proportional to $\frac{m_1 \times m_2}{d^2}$. When two poles of similar strength

are one centimetre apart, and exert upon each other a force of one dyne, the poles are said to be each of unit strength. Let it be clearly understood, however, that the pole of unit strength is but part of the mathematical conception which enables us to map out the field in a manner convenient for the statement of physical laws.

The field we now suppose to be ideally lined out and calculation becomes possible. Its *strength* at any point is the force in dynes which would there be exerted on a unit pole, and the lines of force passing through each square centimetre of cross-section are numerically equal to the force in dynes exerted where the section is taken. A field of unit strength is one in which there passes one line of force per square centimetre, while a uniform field is one in which the lines are uniformly distributed and run parallel to each other. The strength of field, density of field, and intensity of field, are terms indiscriminately employed to express the same thing. A field through which there pass 16,000 lines per square centimetre may be said, therefore, to have a strength, density or intensity of 16,000 C.G.S. units. Hereafter we shall speak of our ideal lines pretty much as if they had an actual existence; but the student, after the explanation we have given, need not be misled by what is simply a more convenient form of language.

9. *Magnitude of the Induced E.M.F.*—We shall not stay to prove the truth of the fundamental laws of induction which we are about to enunciate. These the reader will have to take for granted, as a complete demonstration would carry us much beyond the scope of the present series. We saw in our earlier experiments that the E.M.F. was due to motion in the magnetic field, and that the motion was always such as to produce a *change* in the number of lines of force enclosed by the coils. It is often more convenient when treating of dynamos to consider the generating coils as enclosing lines of force, but it is necessary for the reader to realise that the E.M.F. is really due to the cutting of lines by the conductors constituting the coils.

Let us imagine that we have a uniform field, fig. 22, in which the lines of force are represented by the

horizontal lines. The arrow heads will denote that these lines proceed from a N pole and are going towards a S. If a straight length of conductor, A, maintained perpendicular to this paper were moved from A to B, an E.M.F. will be created in such direction that were a circuit completed by connecting the two ends of the

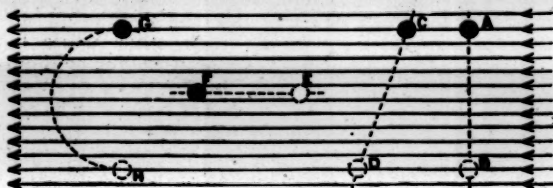


FIG. 22.

conductor by a wire outside the field a current would flow down through the paper. If the movement were from C to D the E.M.F. would be in the same direction, whereas if from E to F there would be no result, the conductor in this case moving parallel to the lines of force and cutting none during the movement. The E.M.F. is proportional to the rate of cutting lines of force, and to produce one volt we require to have one hundred millions, or 10^8 lines cut per second. If the conductor move in a straight line, as from A to B or from C to D, the rate of cutting lines does not vary during the movement, and the E.M.F. is constant. But if the conductor moves in a circular path, as from G to H, the rate of cutting lines will vary at every instant, being nought at the beginning and end of the movement when the motion is parallel to the lines, and a maximum when the conductor is at a and the motion at right angles to the lines. This point becomes clearer when we consider that the circular motion from G to H is compounded of two motions, A to B and E to F at right angles to each other, one component only being available for cutting lines of force. Though the E.M.F. varies at every moment, the average E.M.F. for any

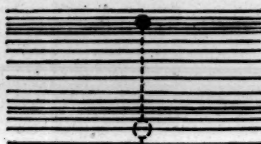


FIG. 23.

movement is proportional to the number of lines divided by the time in cutting them. If the time occupied by the conductor in moving from A to B is the same as that taken by the movement from G to H, the average E.M.F. in the latter case will be equal to the E.M.F. in the former, though in the same time it varies from 0 to maximum and back to 0 again. If the field be not uniform, and the conductor has to move from a dense part to a part less dense, fig. 23, the E.M.F. varies, but the average for a given time is obtained as above by dividing the total number of lines by the time.

(To be continued.)

REPORTS ON ELECTRIC TRAMWAY "SYSTEMS."

A FEW months ago we had occasion to criticise a report on experiments which were carried out with an electric car in one of the South London suburbs. We are always glad to encourage any *bona fide* attempt which may indicate progress in some particular direction, but what we objected to in this instance was the method which the experimenters adopted in showing that electric traction is cheaper than horse traction, their figures having been based upon the results of a trial trip which took place one night over the rails of one of our tramway companies.

Last week we were startled with another and, if possible, more curious report on a different "system." This report we find in our esteemed contemporary the *Electrical Engineer* of August 24th; it was addressed to the chairman of the West Metropolitan Tramway Company by Mr. Gisbert Kapp, who does the projectors the honour of calling a certain combination advisedly, no doubt, "The Lineff tramway system."

According to Mr. Kapp's own description, the car is fitted with a 4 H.P. *Immisch motor*, the power of which is transmitted to the car wheels by means of countershafts and *Renold's chain gear*. "In this respect," says the writer, it "does not differ from that used on other electric cars. There are, however, two special appliances peculiar to the *Lineff car*. The one is a movable dash board at each end of the car, which upon striking an obstacle automatically reverses the direction of rotation of the motor, and causes the car to run back; the other is a magnetic brake." Mr. Kapp thinks that "the putting on of the brake is a good feature, but does not consider the advantages of automatically reversing the motor sufficiently great to compensate for the complication which the arrangement entails." Since that "dash board" is below the floor of the platform, the obstacle must not be more than a few inches in height in order to render the gear active, therefore we cannot see the practical use of such an arrangement, and we are afraid that tramway engineers will eventually look upon this as a nuisance; and when this is removed, what will be left of the "Lineff tramway system?"

Later on we read that this "system belongs to that class where the current is supplied to the car by means of a conductor placed underground; but whereas, in other systems, the metallic surface of the conductor is exposed along its whole length, and a contact brush or slider rubs along it to take the current off, in the Lineff system nearly the whole length of the conductor is insulated, and the current is taken off at certain points, about three feet apart."

Underground conductors have been used for several years on a commercial scale by Mr. Holroyd Smith on the Blackpool tramway, but in this case the conducting surfaces are exposed all the way. Professors Ayrton and Perry, however, six years ago showed that a very long conductor should be divided into short sections; each section would not leak very much, and if only one section at a time was connected with the dynamo machine, the insulation of the longest line was as good as that of a very short line. Thus the leading features of the "Lineff system," the complete specification of which was lodged at the patent office in January, 1888, were clearly demonstrated years ago by Professors Ayrton and Perry and Mr. Holroyd Smith. Mr. Kapp must have been unaware of this, for he emphasises in his report that "in other systems of underground conductors, the metallic surface is exposed from one end of the line to the other, and the leakage resulting therefrom must obviously be very much greater than with Mr. Lineff's arrangement."

The slight variations introduced by Mr. Lineff are, in our opinion, not of sufficient importance to give the combination the name of a "system," nor can we consider these small details "improvements" until they have been tested by prolonged practice.

Mr. Kapp not only does not reveal the fact that the principles of the system he advocates were known and used long ago, but he actually leaves the impression that Mr. Lineff is the originator of the idea, and thus the recipients of his opinions may become confused.

The appendix to the above-mentioned report apparently reveals a lack of practical knowledge which we should not have expected from a man of Mr. Kapp's professional standing. The figures obtained with the insulation tests are of no value, since the playing of clean water for a few minutes or even an hour over or into the channel is not by any means the equivalent of a drenching rain lasting for days, and bringing with it mud and rubbish, which gives the moisture remarkably good conducting qualities. The power tests on a model line one tenth of a mile in length, per-

fectly level, but containing a sharp curve, cannot represent the conditions of actual service on the public roads. "The car was loaded with 40 cast iron chairs, weighing 86 lbs. each, and in addition carrying two persons, the total load being 33½ cwt., and ten runs were made. The average current required was now for full speed 13 ampères, at a pressure of 230 volts on the motor terminals, corresponding to an electrical energy of 4 H.P. for a total rolling load of 3·4 tons." From this test of ten runs over a level line one-tenth of a mile long, Mr. Kapp calculates the power requisite for a complete tramway with full-sized cars, and he estimates the entire working expenses from the assumption that an average of 7½ electrical H.P. will be sufficient to propel each full-sized car over the Kew Bridge and Hammersmith line. We doubt whether with the proposed "system" 12 electrical H.P. per car will suffice to carry the traffic on with safety and keep up an average speed of 7 miles an hour, and after making this statement, it is unnecessary for us to criticise the remainder of the figures in this remarkable report.

MEDICAL ELECTRICITY AND FAITH HEALING.

A MUCH valued friend writes to us from abroad in the following strain:—Your numerous articles and paragraphs on the all healing effects of electricity in its many forms brings vividly to my mind several cases which some of your expert readers may be glad to get as additional testimony to their worth. Speaking of electropathic belts and their cures, I have noticed that in Africa and other Mohammedan continents, the knowing ones of that creed, the Marabouts, always carry on their persons "electropathic" strings of stones. Opinions are divided as to whether this is to remedy their spiritual or material diseases; but one thing is certain, and that is, that these gentlemen are always numerous and healthy. This suggests an immunity from mental and bodily pain, which is either brought about by their easy going lazy life, or more probably by the "electropathic" principles of the stones they carry. The healing influence of these charms is old history in England, and still is made use of among the Cherokees and Apaches of North America, and among the descendants of the Imaris and others of the Southern Continent. In some parts of Cornwall, and in many copper mining countries where the loads of ore are carried from the bowels of the earth on the backs of our fellow creatures, the "electropathic" effects may also be noticed, the continual perspiration and exudation of the fatty acids of the body reacting on the ore through the diaphragm of the skin or sack in which the ore is carried, producing generally a fine healthy body of men.

Sceptics say that the weak ones die off and only the strong remain; but this we cannot believe, with the evidence of electropathists before us.

There is still another field open to these gentlemen, namely, that of complete insulation from their fellows. I have noticed that after the fatigues, mental and physical, of a heavy business day, nothing is so conducive to perfect repose as a complete insulation from our mother earth. The best insulation I have found to be that of feathers carefully dressed out in an inclosed space and laid on a grid, supported by four posts. These may be of wood or iron. If they are carefully arranged, the patient can safely mount on the feather casing, and after stretching himself carefully so as not to touch the cold iron, he will gradually find a relief which develops later into an oblivion of all things worldly. After seven hours of this treatment the patient is generally well enough to resume his work. This surprising effect may be due to the insulating qualities of the feathers, but I have heard of cases in which the insulation of an old suit of clothes is quite sufficient to produce a like effect on a damp doorstep.

To be serious, if some of the gentlemen who trade

upon the credulity of those who can ill-afford the expense, but in their very torture would try anything, if some of these gentlemen had applied to them the quick justice of the racecourse and were immersed in a pond of *aqua regia* the reaction would be a salutary one, and if they could only "keep their hair on" would be a lasting record of their sacrifice to science.

I believe that everyone interested in electrical matters is of opinion that experiments for demonstrating the effects of electric currents on the human body should be carried on, but this feeling is a totally different thing from the haphazard efforts of those who wish to make their living out of the application of an influence of which, in the majority of cases, they are totally ignorant. Should there be any appreciable effect from the vibration which electrical currents produce in the human body, and this I have no wish to deny, surely by the calculation of chances this effect is more likely to produce prejudicial than beneficial effects when applied by men who neither understand electricity nor the intricate composition of the human body. This ignorance may lead them to apply prejudicially the wrong number of vibrations, the wrong voltage, and consequently the wrong current density, and perhaps after all to direct this influence by the wrong channels. The subject is a large one, and is well worthy the attention which is now being given to it by some of the most eminent men, but until it is more thoroughly understood it should not be allowed to become the tool of quacks who not only take the money, but may be damaging the healths of those they profess to cure. In the middle of my cares I have thrown off the above which you can make use of if you think it worth while.

PROPOSED ELECTRIC TRAMWAY IN THE ISLE OF WIGHT.

THE "garden of England" already boasts of an electric railway—that which has proved such an attraction on Ryde Pier—and a movement is now on foot with the view of carrying a scheme into effect for the running of an electric tramway between Newport and Carisbrooke. In connection with this matter a public meeting was held on Thursday week at the Queen's Rooms, Newport, under the presidency of Councillor Bullen, for the purpose of ascertaining the views of the inhabitants on the scheme, which had been refused the consent of the council.

The chairman, in opening the proceedings, said that certain persons were greatly in favour of the proposed tramway, while others were opposed to it. The idea would have been laughed at a quarter of a century ago, but times had moved since then, and the objections which were now raised to the electric tramway were made against the introduction of railways into the island. He did not consider the objections against the present scheme to be substantial. It had been said that the streets were too narrow for a tramway. That was a mistaken idea, as would be seen from information which had been collected from towns which had tramways. The minimum width of the road from Newport to Carisbrooke was 19 feet. At Ipswich the average width was 18 feet 6 inches; at Warwick, 30 feet; at Southport, 20 feet; at Exeter, 16 feet; at Woolwich, 15 feet; at Croydon, 19 feet 4 inches; Sheffield, 14 feet 10 inches; Blackpool, 24 feet; Coventry, 29 feet, and Douglas (Isle of Man), 22 feet. These figures entirely upset the theory that the roads were too narrow. There would, no doubt, be certain conditions accompanying the consent of the council, if it were ultimately secured for the scheme, and if it were arranged that on the company discontinuing the line the materials should become the property of the corporation, the latter would be repaid for the cost of again making up the road.

Mr. J. W. Haynes, engineer, of Forest Gate, gave details of the scheme proposed. He explained that in

consideration of the width of the roads it was only proposed to lay a three feet gauge from Newport to Carisbrooke. With a view to economy electricity would be utilised as the motive power, and while considering that wood paving would be preferable, they would be prepared to lay down any kind of pavement the council might require.

Councillor Salter expressed an opinion that no one would be injured by the proposed tramway, which, on the other hand, would prove a great advantage to the general public. Some £8,000 or £10,000 would be spent in the construction of the line, and that expenditure would undoubtedly do a great deal of good. He moved a resolution to the effect that it was desirable that the corporation should give permission to the promoters to make a tramway from Newport to Carisbrooke.

Mr. Taylor seconded.

In reply to a question it was stated that it was proposed to make the fare from Newport to Carisbrooke 2d., with a 1d. fare for an intermediate distance.

Mr. Salter did not believe that if once the tramway were laid down it would ever be disused. Supposing the first company dropped £10,000, a second company would, no doubt, be willing to come forward with £5,000 and work the line.

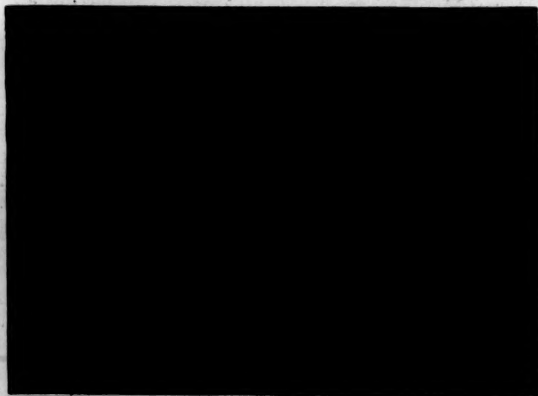
The resolution was then carried *nem. dis.* and the meeting terminated with the usual compliment to the chairman.

A REMARKABLE STROKE OF LIGHTNING.

THE storms which raged during the end of July over the south-east of France, and which were exceptionally violent, have given rise to several interesting observations. We (*La Lumière Electrique*) know that in compliance with the wish expressed by the Congress of Electricians in 1881 and 1884 all the managers of telegraph offices were directed to draw up an account of the strokes of lightning and to mention all the details observed regarding these phenomena.

There is often reason for regret that the description of a particular case is not accompanied by a sketch or figure. It is to be wished that photography would come to the aid of these official forms; the study of strokes of lightning would be greatly assisted thereby.

The accompanying figure, for example, tells us more than a long description would do.



It represents in its actual size a sheet of paraffined paper, introduced between the line and earth plates of a telegraph lightning conductor, of the kind that is furnished with a gutta-percha plate. In its normal condition the sheet is between two strong metal plates, one of which is traversed by the line current and the other is connected to earth.

A moderately strong discharge usually perforates the insulating paper and goes to earth through the lower

plate. Generally the sheet is pierced in one or two places with a pin-hole surrounded by a black or reddish circle from 3 to 5 millimetres in diameter.

At the office of Gréasque (Bouches-du-Rhône), in spite of the plates, the paper was perforated, violently torn in the form of stars, measuring as much as 30 millimetres in their widest part, and drawn from the centre to the periphery into an infinite number of very close folds.

On examining the plates that had been struck we found upon the bronze two black star-shaped stains forming the counterpart of the parts destroyed. In the centre of these black stains was a bright point formed of a globule of melted metal. The exceptional dimension of these openings, and their elegant form, render them worthy of examination by meteorologists.

REVIEW.

A Practical Treatise on the Steam Engine Indicator and Indicator Diagrams. By AMICE. Edited and enlarged by W. WORBY BEAUMONT, M.I.C.E. London: The "Electrician" Printing and Publishing Company, Limited. 1888.

This little treatise, though of small bulk, contains a deal of information of a very practical character. In his preface the author remarks the care he has taken to avoid lengthy discussion of theoretical or hypothetical matters which, though of great scientific importance, do not immediately concern those whose desire is to understand the practical employment of the indicator and to correctly interpret its diagrams. Part I. deals with the use of the indicator diagram, and describes the different forms of indicator amongst which are included the later types—Kraft's, not often seen in this country, Darke's and Crosby's. These indicators, as may be known to our readers, have quite supplanted the older Richards form for indicating fast-running engines. Part II. is devoted to the methods of attaching the indicator and to the apparatus for actuating it. The author justly remarks that additional accuracy is secured by attaching a separate indicator to each end of the cylinder instead of employing, as is usual, one indicator with a connecting pipe having a two-way communication cock. Part III. introduces us to the study of actual diagrams and their departure from the hyperbolic curve given by Boyle's law is dwelt upon in Part IV. Theoretical considerations regarding isothermals, adiabatics, the actual expansion curve of steam and the effect of the steam jackets find a place in this part of the work. Parts V. and VI. deal with compound engine diagrams, and in Part VII. we are shown how to combine the high and low pressure cards for the purpose of showing the losses due to condensation. Parts VIII.—X. deal with all kinds of diagrams under all circumstances of load from simple, compound and triple expansion engines. The author's remarks in Part XI. seem to point to a conclusion which we have held for some time, namely, that the real gain in advancing from triple to quadruple expansion is at the present moment somewhat hypothetical. By this advance we do not refer to the mere use of four cylinders instead of three, but we imply the higher ratio of expansion which quadruple engines naturally suggest. In many cases it might be preferable to have two pairs of tandem cylinders side by side having consequently four expansions than three single cylinders side by side. But what we question is the nett gain in using much higher pressures than are usual at the present time, and which bring along with them difficulties of an entirely novel character. Part XII. gives the diagrams obtained from locomotive engines, and we should recommend an earnest consideration of this portion of the work to our friends whose energies are now misapplied in the direction of locomotion on the Underground Railway. Part XIII. deals with gas engine diagrams, and Part XIV. on the measurement of diagrams concludes the work. Although, as the

author says, the planimeter has been described in many works, we think it a pity he did not devote a few pages to its description and proper use. The indicator and indicator diagrams have been described in many books, but the author found in this fact no reason for leaving his book unwritten. No more in our opinion does the fact mentioned above constitute a good reason for omitting a description of the planimeter. This work is most lucidly written, is of a thoroughly practical character, and should be found on the bookshelf of every engineer.

NEW YORK BOARD OF ELECTRICAL CONTROL.

RULES AND REGULATIONS.

ELECTRICAL conductors are divided into two classes:—1. Those for telegraph, telephone, and similar service. 2. Those for electric light and power, and similar service.

II. No two lines of poles bearing conductors of like class shall be erected on any street or avenue.

III. No two lines of poles shall be erected on the same side of any street or avenue.

IV. All conductors of the second class shall be screwed to insulating fastenings, and covered with an insulation which is waterproof on the outside and not easily worn by abrasion. Whenever the insulation becomes impaired it must be renewed immediately.

V. Poles shall be placed upon the sidewalk, as near the curb as possible, and no pole shall be placed within 10 feet of any lamp-post or other pole.

VI. All existing regulations of the local authorities in regard to the placing of poles and stringing of wires are to continue in force, and the rules and regulations of the New York Board of Fire Underwriters' must be strictly observed.

VII. All wires shall be fastened upon poles or other fixtures with glass, porcelain, or rubber insulators.

VIII. No wires of the second class shall be stretched within one foot of any pole without being attached to the same with glass, porcelain, or rubber insulation.

IX. No wires of the second class shall be stretched within 12 feet of the ground or within 2 feet of any building, except when attached thereto with glass, rubber, or porcelain insulators.

X. No electrical conductors shall be stretched over any part of any house or other building, or attached thereto, except by permission of the owner thereof, and all conducting wires of the second class must be at least 7 feet above roofs, and placed so as to avoid ladders of the fire department and shutters.

XI. The companies or persons owning or controlling poles in any street or avenue shall allow the same to be used by other companies or persons operating conductors for similar electrical service when authorised so to do by the board, on tender of proper compensation, to be determined by agreement between the parties interested. In default of such an agreement the amount of such compensation shall be determined by the board. This rule imports a contract on the part of each company or person owning or controlling the poles in any street or avenue, not only with the board, but also with each company or person who shall under its terms be qualified to demand the privileges it confers.

XII. All permits of the board for overhead wires and fixtures are granted only pending the providing of underground accommodations in the neighbourhood of the street or avenue for which the permit is granted.

XIII. Any member or officer of the board, and every inspector employed by it, as well as every member of the police force of the city, shall be entitled to examine permits under which work of any kind is being done.

XIV. No permit shall be granted for the erection of any overhead structure nor for the renewing of any lines already existing in any street, avenue, or highway, in which underground accommodations for the service have been provided, or are being provided.

XV. All poles now standing, or to be hereafter erected, shall be branded or stamped with the initials of the company owning them, at a point not less than 5 nor more than 7 feet from the street surface. When an odd pole is taken down it must be removed from the street the same day. New poles must not be brought upon any street more than two days in advance of their erection. Any pole that shall lie on any street more than two days shall be removed by the bureau of incumbrances of the department of public works, at the expense of the party owning it.

XVI. All companies or persons having poles in the public streets shall give a bond to the city in a reasonable amount, to be determined in each case by the board, conditioned for the payment of the cost of removing dangerous and abandoned poles, and also for the payment of the expense of restoring the sidewalks and pavements where the same have been disturbed or injured in consequence of the erection or removal of any pole owned by them.

XVII. The violation of any of the rules and regulations of the board shall operate *ipso facto* by a revocation of the permit held by the company or person guilty of such violation.

XVIII. Whenever hereafter any company shall be permitted by this board, or its successors, to erect posts or poles, or other fixtures bearing lamps or other devices for the purpose of lighting by electricity the streets, avenues, highways, parks or public places of the city, the said permission shall be granted only subject to the following provisions, and the same is hereby expressly made a condition of said permits: At any time when, by action of the city authorities, the contract for lighting any such street or other public place shall be given to another company, the company erecting said lighting fixtures or lamp-posts shall, on tender of the first cost thereof, yield possession and ownership of the same to the said other company obtaining the new contract.

XIX. Electric light lamp-posts shall be in accordance with the plan adopted by the board.

XX. All broken and "dead" wires, and all wires, poles, and fixtures not actually in use, must be removed from the streets, avenues and highways of the city.

PERMITS.

XXI. The general permit, giving electrical companies the right to repair their lines of conductors where needed, is continued and made obligatory upon said companies. This general permit does not, however, cover the erection in any street, avenue or highway of any new poles or other similar fixtures, and has absolutely no reference whatever to lines which have been ordered underground by the board, and which the mayor has been requested to remove. In the case of such lines, where notice has been given that underground accommodations have been provided, and the 90 days of notice required by law have elapsed, and the mayor has been requested to remove the same, companies owning or operating said lines are not authorised to make any repairs or connections or to go upon the poles bearing such lines for any purpose whatever, except to remove the said lines of electrical conductors in conformity with the directions of the board. Any deviation from this rule requires a resolution passed at a regular meeting of the board, attested by the secretary.

XXII. The secretary is authorised to issue to companies operating electrical conductors of the first-class, all permits required by them for the making of connections necessary to the business of said companies with lines now in use, and which the mayor has not been requested to remove, not including the erection of any new poles or similar fixtures—said connections to be in every case in accordance with the rules and regulations of the board.

XXIII. No poles, lamp posts or other similar fixtures shall hereafter be erected in any street, avenue, or highway, except upon resolution passed at a regular meeting of the board, attested by the secretary.

XXIV. No conductors of the second class shall hereafter be placed above or under any street, avenue, or highway, except upon a resolution of the board, passed at a regular meeting, attested by the secretary.

XXV. No applications for permits for the erection of poles or the placing of wires of the second class, will in any case be considered by the board, when made by companies owning or operating electrical conductors in violation of these rules and regulations, or in defiance of any order of this board.

XXVI. These rules and regulations are subject to revision and alteration.

The following were added to the rules and regulations July 2nd, 1888.

DAY CIRCUITS.

All circuits which ever carry a current exceeding 500 volts, between 9 a.m. and 4 p.m., must be painted red for a length of 2 feet at each insulator.

NUMBER OF CIRCUIT.

Every electric wire carried on poles must be indicated by a number plainly marked on each cross arm under the insulator.

STATIONS.

All circuits must be tested every hour when in operation, and when a ground comes on, effort must be made to remove it at once; failing in this, the current must be discontinued until the insulation is restored.

CERTIFICATE OF INSPECTION.

From and after August 1st, 1888, no company shall do business of arc electric lighting in the city of New York without a certificate of the board, granted on recommendation and after inspection by the expert of the board, to the effect that its lines comply with all the rules and regulations of the board, and that its plant is in proper condition for the doing of its business. The force of the certificate to continue until changes are made, of which the board must be notified and approve, or so long as the plant and conductors remain in the same condition as when inspected.

WHITWORTH SCHOLARSHIPS.

The following, from the *Glasgow Herald*, gives a very concise account of the rise and progress of the Whitworth Scholarships, and we reprint it in the interests of embryo electrical engineers, to whom the competition is open as well as to mechanical engineering students. We may state, as a matter of some interest, that by its successes this year the Glasgow Technical College, presided over by Principal Jamieson, has provided 32 Whitworth scholars, the total value of the scholarships thus gained being £1,250.

It is now 21 years since Sir Joseph Whitworth made the munificent offer to found scholarships, involving an annual outlay of £3,000, for the further instruction of young men, selected by open competition for their intelligence and proficiency in the theory and practice of mechanics and its cognate sciences, with a view to the promotion of engineering and mechanical industry in this country. From 1869, when the first competition was held, to 1879, the Whitworth scholarships were of the value of £100 a year, and tenable for three years. At first ten were awarded annually, but in 1873, in order to ensure the devotion of the scholars to the studies and practice necessary for mechanical engineering, the number of scholarships was reduced to six, and a system of extra payments was instituted on the results of examinations held during the tenure of the scholarship, so that the best scholar of a year's batch could obtain as much as £800 in all, and the others in proportion. From 1880 to 1887 the scholarships were awarded for one year only, and without bonus, there being usually one of £200, eight of £150, and sixteen of £100.

The experience of past competitions led the Science and Art Department last year to again revise the rules for the administration of the Whitworth endowment. As before, candidates must be under 26 years of age, and have been engaged at handicraft for at least three years in the workshop of a mechanical engineer; but henceforth some of the awards are to be known as exhibitions tenable for one year, and others as scholarships tenable for three years. Both exhibitors and scholars require to follow out a course of work or study satisfactory to the department. While doing so exhibitors are permitted to hold posts of profit or emolument as well as the royal exhibitions and national scholarships of the Science and Art Department, but scholars will be required to devote their time *entirely* to the prosecution of their education as mechanical engineers, and cannot hold royal exhibitions or national scholarships. Exhibitors and holders of one year scholarships are eligible for the three year scholarships. These changes appear to us to be in the right direction; an immediate effect has been to render the competition for Whitworth scholarships this year excessively keen. The awards have just been issued, and include four scholarships of £125 a year for three years, 20 exhibitions of £100, and 10 of £50 for one year.

We are glad to see that there is no breach of continuity in the success of the students of the Glasgow and West of Scotland Technical College, which, in racing phraseology, holds the record for Whitworth scholarships. When we mention that the students of this college have during the past four years gained no less than 23 scholarships—value £2,850—it will be readily admitted that to beat this splendid record, as has just been done, reflects the highest credit on all concerned. This year's successes comprises two scholarships of £125 a year each for three years—the 2nd and 4th; six exhibitions of £100—the 3rd, 4th, 10th, 12th, 17th, and 20th; and one exhibition of £50—the 7th; total value, £1,400. The 8th £100 exhibitor was for several seasons a student here, so that the college deserves some credit for his success also. Having enumerated these Glasgow honours, there is nothing further to record for the rest of Scotland; this is another matter in which Glasgow has been singularly favoured in this year of grace. As showing the severity of the competition this year, we note that the first and third men were first in the Whitworth lists for 1887 and 1886 respectively, and the fourth man second in 1887; the second man does not appear to have been present at any previous competition. Subjoined is the complete list:—

I.—SCHOLARSHIPS, TENABLE FOR THREE YEARS, OF £125 A YEAR.

1. J. Whitaker, Nelson, Lancashire.
2. J. Mair, Glasgow (Technical College).
3. C. H. Gilbert, Nottingham.
4. J. Calder, Glasgow (Technical College).

II.—EXHIBITIONS, TENABLE FOR ONE YEAR, OF £100.

1. H. Bamford, Oldham.
2. J. Harbottle, Newcastle-on-Tyne.
3. J. Taylor, Glasgow (Technical College).
4. J. Dalglah, Paisley (Glasgow Technical College).
5. A. S. Younger, North Shields.
6. J. Butterworth, Rochdale.
7. G. A. Burls, Greenwich.
8. C. H. Kilby, Crewe.
9. C. R. Pinder, Bristol.
10. E. Dumas, Glasgow (Technical College).
11. C. L. E. Heath, Devonport.
12. C. Forbes, Glasgow (Technical College).
13. B. Young, Belfast.
14. E. Y. Terry, Devonport.
15. W. J. Collins, Woolwich.
16. J. H. B. Jenkins, New Swindon.
17. J. I. Fraser, Glasgow (Technical College).
18. H. E. Cheshire, Crewe.
19. O. Brown, Plumstead.
20. H. Elliott, Glasgow (Technical College).

III.—EXHIBITIONS, TENABLE FOR ONE YEAR, OF £50.

1. J. H. Binfield, Preston.
2. G. N. Wheeler, London.
3. W. Day, Wolverton.
4. S. Lea, Crewe.
5. E. Parry, Bangor.
6. T. O. Mein, Stratford, E.
7. B. Connor, Glasgow (Technical College).
8. T. J. Bourne, Tunbridge Wells.
9. G. Ravenscroft, Crewe.
10. T. F. Parkinson, Bury, Lancashire.

For 1889 four scholarships of £125 a year, ten £100 exhibitions, and twenty £50 exhibitions will be open for competition in the following subjects:—Practical geometry, machine drawing or building construction or naval architecture, mathematics, theoretical and applied mechanics; sound, light, and heat; magnetism and electricity, inorganic chemistry, metallurgy, steam, and free-hand. Of these, practical geometry, mathematics, and theoretical mechanics are compulsory subjects, in which a certain pass must be obtained.

THE ALTERNATING CURRENT DECISION IN BOSTON.

CIRCUIT COURT OF THE UNITED STATES, DISTRICT OF
MASSACHUSETTS, IN EQUITY.

Westinghouse Electric Company v. Sun Electric Company, et al.
No. 2,377.

OPINION of the Court, August 7th, 1888:—

COURT, J.: This suit is brought to enjoin the defendants from infringing letters patent No. 351,589, granted October 26th, 1886, to George Westinghouse, jun., assignee of Lucien Gaulard and John D. Gibbs, for improvements in methods and apparatus for the distribution and conversion of electric energy.

The case has been thoroughly and ably represented on both sides. The patent relates to that branch of the art of electric lighting known as the incandescent. The specification states that the "invention relates to the distribution of electrical energy for industrial purposes; and it consists in an improved art or method and an organization of apparatus, whereby the same is carried into effect, by means of which we are enabled to transmit from a central or supply station, through a main conductor, a primary electric current of comparatively small quantity, but of high potential, and at a point or points more or less distant, where the said electric energy is to be utilised, to transfer the energy residing in such primary current of high potential into one or more secondary currents of lower potential, but of greater quantity."

At a point where the electric current is to be utilised for any suitable purpose—as, for instance, in one or more incandescent electric lamps—we place one or more secondary generators or converters. The general principle of our secondary generator is analogous to that of the well-known inductorium, or induction coil, with this exception, that while the induction coil has heretofore usually been employed to transfer electric energy from currents of low potential and great quantity into currents of high potential and small quantity, the function of the secondary generator or converter, as applied in our invention, is precisely the reverse of this, namely, to transfer electric energy from currents of high potential to currents of low potential and increased quantity. We have constructed converters for effecting this result in a variety of forms, all of which involve the same principle. The most important and characteristic feature of our invention is that which renders it possible to make use of alternating and equal positive and negative currents of moderate quantity, but of very high potential in the primary or main line circuit, and to convert these into secondary or induced currents of much greater quantity, but of correspondingly lower potential at the place of consumption, which secondary circuits are employed to do the required work. Any required number of converters of the general construction described may have their primary circuits united with or included in the conductors leading from the primary generator. The manner of connecting such converters, whether in series, multiple arc, multiple series, or otherwise, will be understood by those skilled in the art to which our invention relates without the necessity of further explanation.

The specification then says that one arrangement is indicated in fig. 3 of the drawings, which shows an arrangement of converters in series. Then follows this disclaimer:—"We do not herein claim the connection of the converters in the line in any other arrangement than we have illustrated in the drawings." Fig. 3 of the drawings shows an arrangement of converters in series. The defendants connect their converters in what is known as the multiple arc system, which is quite different in construction and mode of operation from the series system.

There are five claims in the patent, the first being for the art or method, and the remaining four claims for the apparatus.

The first question which arises relates to the proper interpretation of the patent in view of the disclaimer. Undoubtedly, as originally drawn, the patent was intended to cover all forms of converters which transferred electric energy from currents of high potential to currents of low potential and increased quantity, whether connected in series, as indicated in fig. 3 of the drawings, or in multiple arc or otherwise. The Patent Office refused to grant so broad a patent and instructed the applicants that, in order to avoid an interference, they must confine the arrangement of converters to the series system, that being the arrangement shown in the article in *Engineering*, of March 2nd, 1883, which the applicants declared contained a description of their invention. Thereupon the disclaimer was inserted. An examination of the file wrapper and contents discloses that the Patent Office believed this patent should be limited to the arrangement of converters in series, and that this was supposed to have been effected by the disclaimer; otherwise an interference would have been declared.

The patentees avoided such interference by inserting the disclaimer, and it is too late now to say that the disclaimer means in effect nothing. If we construe the patent to cover broadly a dynamo producing alternate currents of high potential with a single reducing converter, then the disclaimer is meaningless, because such construction would embrace converters connected in multiple arc or otherwise.

The patent states that the invention is for a system of electric distribution; the true scope, therefore, of the invention is not confined to one converter, but to several converters arranged in a system, and, when the patentees disclaim all systems but the series, they should be held to it.

As we have said, Gaulard and Gibbs declare that the invention covered by the patent in suit is found in the article in *Engineering* of March 2nd, 1883. The defendants deny that the article describes converters which transform the current from high potential to low. Whoever may be right, it appears quite certain that the high potential of the primary, and the low potential of the secondary, or the long thin primary wire and the short thick secondary wire, which become so important in the patent under consideration, are not specifically described or shown with clearness in the article in question. The system described in the article was a general one, and was intended to meet the conditions laid down in the English Electric Lighting Act, which provided that the "undertakers" shall not prescribe to householders and others, to whom they supply the current, the use of any particular kind or form of lamp. The Gaulard and Gibbs invention has a two-fold object, says the article: "Firstly, it aims at rendering it practicable for undertakers to supply current at the most economical potential permitted by the terms of their provisional orders; and, secondly, it is intended to make the user independent of the producer, and to enable him to apply the current he receives to any purpose he may please, such as arc lighting, incandescent light, the generation of power or of heat." If the article does show a converter which transforms electric energy from high potential to low, it is evident that Gaulard and Gibbs did not at this time regard this as a great discovery, or it would have been more clearly indicated. Undoubtedly, the article was intended to outline a general system to supply to customers currents of high or low potential, as might be desired, by means of converters connected in series based upon the principle of the Ruhmkorff coil, but that this was to be accomplished by means of a primary current of high potential and secondary currents of low is not apparent.

Further, if the reducing converter, now made so important, was discovered by Gaulard and Gibbs, in March, 1883, and constituted such a great invention, why did it not form the subject matter of their subsequent American patent of April 29th, 1884, and British patent of September 13th, 1883?

These things go to prove that the prominence given to the reducing converter in the patent in suit was based upon something else than the article in *Engineering*. I am led to think that it was based upon the fact that, between the date of the article and the date of the patent in suit, other inventions had come to light, and that it was these improvements which induced Gaulard and Gibbs to set up the claim they make in their last patent.

In the patent granted to E. Thomson, July 14th, 1885, the converters are arranged in series. The object of the invention was to provide a safety switch for the converters, but we there find described the primary or main current of high potential and the secondary current of low potential. The specification says: "The secondary coil is wound with such coarse wire, and the lamps used therewith are of such low volt potential as not in itself to produce dangerous discharges or shocks." Thomson seems to take it as a matter of course, in view of the prior state of the art, that there was no invention in reduction from high potential to low through a converter.

But the most important improvement was made by Zipernowsky and Déri in their English patent of March, 1885. This patent describes minutely a system of distribution by induction through potential-reducing converters combined in multiple arc, and it includes an alternating current dynamo generating a current of high potential.

We see, then, that the state of the art in 1883, when the article in *Engineering* was written, and in 1886, when the patent in suit was issued, was quite different. It became very important, therefore, for Gaulard and Gibbs to obtain a patent for a single reducing converter, however it might be combined with others in a system. I think the importance given to this point in the patent, an effort to expand the real invention of Gaulard and Gibbs, as contained in the article in *Engineering*, and that the Patent Office intended and did in effect limit the patentees to all they were fairly entitled to, namely, the arrangement of their converters in series in a system of electric distribution.

By assuming that our interpretation of the effect of the disclaimer is wrong, and that Gaulard and Gibbs are entitled under their patent to claim the exclusive right to a converter which transforms energy from high potential to low in combination with a dynamo producing alternating currents, can so broad a claim be sustained in view of the prior state of the art?

To uphold this position, of course, Gaulard and Gibbs have to go back to the article in *Engineering* of March 2nd, 1883, as the date of their invention, because this form of converter in combination with an alternating dynamo is clearly shown, as has been observed in the Thomson and Zipernowsky and Déri patents of 1885. But, admitting that the date of the invention was March 2nd, 1883, I have much doubt whether Gaulard and Gibbs could obtain a lawful patent for so broad a claim. The counsel for the

plaintiffs in his closing argument admits that the induction coil or inductorium or converter, in its general sense, as a device used for taking off from the line at different points a portion of the electric energy, whether of the same or higher or lower potential, was well known. The article in *Engineering* states that the secondary generator or converter was based upon the same principle as the Ruhmkorff coil. In the English patent granted to Paul Jablochhoff, November 9th, 1877, we find described a system for producing and dividing electric lights which consisted in carrying a main alternating current round an unbroken circuit and transferring its energy by means of induction coils to consumption circuits at the points where it was to be used. The converters are placed in series with one or more lamps in the secondary of each converter. But it is said that Jablochhoff contemplated a conversion from low to high potential, the reverse of Gaulard and Gibbs. At the same time it was well known that the converter would transfer energy from high to low, or low to high, as the primary wire was longer or shorter. Was it invention for Gaulard and Gibbs simply to reverse the coils and transfer the energy from high to low?

In the English provisional specification of Edwards and Normandy, Nov. 13th, 1878, the inventors propose to use either interrupted or alternating currents with a converter near every place where the light is to be produced. The specification says: "At or near every point where it is required that a light shall be produced, we arrange a coil (or series of coils) of insulated metallic wire or ribbon (preferably surrounding a bar or wires of soft iron), through which coil or coils the current from the principal wire first described can be passed when desired, or out off by means of a key or lever. Round or adjacent to each coil of insulated wire described, we form one or more secondary coils of insulated metallic wire or ribbon, arranged so that the passage of the rapidly intermittent current of electricity, as described, through the primary coil or coils generates a corresponding amount of electricity in each of the secondary coils. In order to facilitate the production of the induced electricity, and to diminish its intensity and increase its quantity, we prefer making the coil or coils in which the electricity is induced of a number of insulated wires or ribbons made up into a bundle or rope, the ends of the wires or ribbons at each end of the bundle or rope being in metallic contact with each other, which united ends are then joined to the conductor conveying the induced electricity." Here is found distinctly stated the principle of a reduction from high potential in the primary to low potential and increased quantity in the secondary, which Gaulard and Gibbs assert is their great discovery.

The patent to J. B. Fuller, Nov. 26th, 1878, is for an improvement in induction apparatus for lighting by electricity. This invention embraces converters arranged in series like those of the patent in suit to be operated upon by an alternating current. It is not stated whether the potential is to be raised or lowered in the converters, but the drawings appear to indicate that it was to be raised.

In the English provisional specification of J. H. Johnson, December 24th, 1878, while the inventor contemplated the raising of the potential in his converters, yet he says, "the apparatus may be connected together . . . in such a manner as to augment either the tension or the quantity of the current."

Thomas A. Edison took out a patent May 26th, 1883 (the application having been filed August 14th, 1882), for an apparatus for translating electric currents from high to low tension. In his invention he uses a continuous current of high tension in the main circuit, and reduces it to a continuous current of low tension in the secondary circuit.

This incomplete review of the prior state of the art would seem to show that at the date of the article in *Engineering* there was no invention in a single converter which transferred energy from high to low potential, as distinguished from a conversion from low to high. It seems to have been assumed in prior patents as a matter of common knowledge that, by the laws governing the inductorium or converter, the electric force transferred could be either of the same potential or of greater or less, as might be desired. It required something further, something that might be called invention, to solve the problem of a successful system for electric distribution. Gaulard and Gibbs undoubtedly believed that, in the article in *Engineering*, they unfolded to the world a description of a successful system. So far as their system was a new invention, and is found incorporated in the patent in suit, they are entitled to be protected. But they are expressly limited by their disclaimer to the series system, and, therefore, the defendants who use the multiple-arc system do not infringe.

Without entering further into the defenses raised, I am satisfied, for the reasons given, that the bill should be dismissed.

Bill dismissed.

Legal Decisions.—It seems odd that a judge who decides that the conversion of high into low tension currents and *vice versa* by means of induction coils was common knowledge at the time of Gaulard and Gibbs's patent, should decide that there is any invention in the method of connecting up these apparatus in series, and that those who employ them in parallel do not infringe. The coupling up of any or all electrical apparatus, whether in series or parallel, was common knowledge many years before Gaulard and Gibbs or Zipernowsky-Déri were ever heard of.

LIGHTNING.

By S. A. VARLEY.

(Continued from page 225.)

In the earlier of the two lectures lately delivered by Prof. Lodge, reference is made to a lightning discharge which struck St. George's, Leicester. The electric current is stated to have passed down the vane rod halfway down the spire, "where it blew a ring of stones out and so dropped the top half of the spire neatly inside the bottom half."

It is not mentioned whether this church had any lightning conductor, but I presume it was so protected. My chief reason, however, for referring to it is that it reminds me of a somewhat similar case which occurred at Doncaster, which was described, if I remember rightly, by Sir Edmund Beckett Denison. The vane rod of Doncaster Church passed through the crown of the tower, protruding some feet inside below the roof and terminating in the air. The conductor outside was connected at its upper end to the vane rod above the masonry. The lightning discharge struck the vane rod and the electricity passed through it into the inside of the tower, leaping from the lower end of the rod through the air to the conductor outside, knocking out blocks of stone and bringing down a mass of masonry much in the same way as occurred at St. George's, Leicester.

I have observed a similar sort of action to what occurred at Doncaster in several instances where telegraph wires have been connected to a multiple protector. Fig. 4 represents a top view of a 4-wire protector and fig. 5 the same in elevation. Supposing



FIG. 5.

FIG. 4.

No. 1 line has been struck and the discharge has passed across the air space separating the end of the terminal block marked A to the earth block, E, which will be indicated by the burning of the metal in the neighbourhood of the air space, it will be observed almost invariably that burning has taken place also on the opposite side at the end of the terminal block marked B. In some cases more or less burning will be observed to have occurred at the ends of all the terminal blocks, the chief burning taking place in a pair of the terminal blocks on the opposite sides. I have by me an example which I have preserved in which 6 out of 8 blocks have been burned, the chief burning occurring in two places on opposite sides of the earth block. What I have now directed attention to would seem to indicate that a lightning discharge, possibly by setting up motion in the atoms composing the conductor, imparts momentum to them, and that the blow struck by the lightning at Doncaster threw the atoms of the vane rod into so rapid a state of motion as to break down the organisation of the air and enable the electric discharge to pass through it and force out the masonry in its passage to the conductor outside.

To illustrate the views receiving the support of Prof. Lodge, some very interesting experiments were performed at the second lecture, which are illustrated and described in the *Society of Arts Journal*.

The first of these is shown at fig. 6, which has been copied from the *Journal*, containing the report of the lecture, and in reference to which it is stated:—

"The first form of experiment I have to describe is a very simple one. I call it the experiment of the alternative path; it consists in giving a Leyden jar discharge the choice between a certain conductor and a certain length of air, and in adjusting the length of air until it had lief take one path as the other.

I am not aware that the particular mode of carrying out this simple experiment has any special significance; but to be definite, I depict the symmetrical arrangement I have most frequently, but not exclusively, adopted.

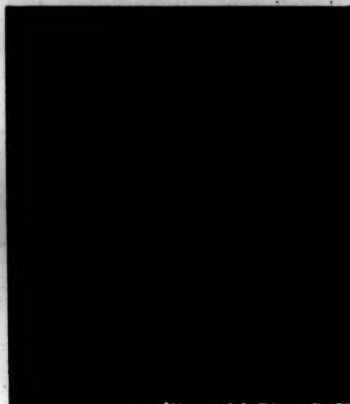


FIG. 6.

The knobs marked A are the ordinary terminals of a Voss machine, the jars stand on an ordinary wood table, and their outer coats are led to the discharger, B, the distance of whose air space can be varied. The alternative path is shown by a dotted line. The discharge has to choose between B and L. Sometimes L is absent, and in that case the charging of the jars is quite well effected through the wood of the table; this is the advantage of having the jars imperfectly insulated. At the same time, the conducting power of the wood is too low to enable the jars to discharge themselves at all satisfactorily, unless the knobs, B, are within striking distance, or unless some path, L, is provided. The only discharge obtained at A, when both the paths, B and L, are absent, is a feeble spitting of intermittent and frequent sparking, very different from the loud report heard as soon as the knobs, B, are brought within striking distance. But it is not to be supposed that the B knobs must be as close together as the A knobs in order to permit complete discharge; on the contrary, the B knobs may be almost twice as far apart as the A knobs, and yet the charge may be complete and noisy.

It will be understood that the two sparks occur together; a spark at A precipitates and is the cause of the spark at B; not *vice versa*, for until the A spark occurs there is not the slightest tendency for a spark at B. The two B knobs are at the same zero potential, and may be touched with impunity except at the instant the flash occurs at A. Remember, the jars are standing on a common table all the time."

I confess that I cannot follow the reasoning from which it is concluded the spark, A, precipitates, and is the cause of the spark, B, not *vice versa*, but I pass on to the consideration of the results obtained, which I regard as much more important as well as more interesting.

Prof. Lodge states: "the spark, A, was very loud whenever the spark was allowed to occur at B as well; but so soon as the discharge was compelled to traverse the alternative conductor, L, by putting the B knobs too far apart the noise of the discharge was much diminished, not merely because there is only one spark instead of two, but plainly because, for some reason or other, the discharge meets with considerable obstruction in the wire, whereby its duration is lengthened, and its noise, therefore, greatly lessened."

In the experiments described the length of the A

spark was maintained at one inch, and as it was found convenient to measure the lengths in tenths of an inch, the A length was called 10.

The first alternative path consisted of 40 feet of No. 1 (B.W.G.) copper, suspended round the room by silk ribbon; and it was found the discharge refused to take this apparently easy path, and to persist in jumping the air gap, B, until the B knobs were separated 14·3 tenths of an inch, which was the critical distance, for when the B knobs were separated further apart the discharge chooses the copper wire.

Now when a length of fine iron wire (No. 27, B.W.G.), whose resistance was 1,300 times as great as that of the copper wire was substituted in its place, it was found that the distance separating the B knobs had to be reduced to 10·3 before the critical spark length was reached.

In other words, the discharge took place more readily through the fine iron wire than the much thicker copper one, a result (Prof. Lodge says) that surprised him.

The summary of the results obtained with different sizes of copper and iron wires, the A spark length being 10, all the time is given as below:—

Alternative Paths.		Critical B spark lengths.	
Stout Copper wire	No. 1 — z =	·025 ohms ...	14·3
Ordinary copper wire,	No. 19 — z =	2·72 " ...	13·4
Stout iron wire,	No. 1 — z =	·066 " ...	10·8
Ordinary iron wire,	No. 18 — z =	3·55 " ...	10·8
Thinned iron wire,	No. 27 — z =	33·3 " ...	10·3

Professor Lodge remarks in respect to the above:—"The copper wires seem to obstruct almost equally, and the iron wires also obstruct equally among themselves, notwithstanding their very different diameters; but the coppers obstruct more than the irons."

Under the heading "Reason of the Enormous Obstruction offered by a good Conductor," it is stated: "Now what is the cause of all this astonishing obstruction offered by good conductors to the sudden rush of electricity?" One may express it in a popular way, thus:—It is due to electrical inertia, or what is also called "self-induction." "A current cannot start in a conductor instantaneously any more than water in a pipe can start moving at full speed in an instant. Give the water a violent blow to make it move, it resists like a solid. The blow if very quick and violent may burst the pipe, but it will not appreciably propel the water so in a manner is it with electricity. The flash occurs, and the conductor must either carry it off at once or not at all. There is no time to think about it, and the E.M.F. needed to overcome this inertia like obstruction is so great that a considerable thickness of air may be burst by it and the discharge may flash off sideways to anything handy." Further on it is stated in this part of the lecture, there is another fact which it behoves us to be aware of. It is one to the importance of which the attention of scientific men has but recently been called. Experimentally it has been discovered by Prof. Hughes, theoretically by Mr. Oliver Heaviside, Lord Rayleigh, and Prof. Poynting; for though the necessary theory is really contained in Clerk Maxwell, it required digging out and displaying. This has now been abundantly done, but the knowledge has scarcely yet penetrated to practical men; indeed, it has not yet been thoroughly assimilated by most physicists. The fact is this. When a current starts in a conductor, it does not start equally all through its section, it begins on the outside, and then gradually though rapidly penetrates to the interior. A steady current flows uniformly through the whole section of a conductor, a variable current does not. It is started first at the surface, and it is stopped first at the surface.

Remembering the rapidly oscillating character of an electric discharge, remembering also the fact that a rising current begins on the outside surface of a conductor, we perceive that, with a certain rate of alternation, no current will be able to penetrate below the most superficial layer or outer skin of the conductor at all. In the outer skin, of microscopic thickness, electricity will be oscillating to and fro, but the interior of

the conductor will remain stolidly inert and take no part in the action.

Thus we arrive at a curious kind of resistance, caused by inertia in a roundabout fashion, and yet a real resistance, a reduction in the conducting substance of a rod, so that no portion except that close to the surface can take any part in the conduction of these rapidly alternating currents or discharges.

Now, notwithstanding the distinguished names mentioned, and who are credited with having theoretically and experimentally demonstrated that electricity (unlike water and other fluids) commences to flow through the outside of a conductor, I take leave to doubt it, and I express this opinion with the greater freedom, as I believe the correctness or incorrectness of these newer views can be determined by experiment. I may here state that, in conjunction with Mr. Wimshurst, I have tried some experiments to try and settle this point. These experiments are not yet completed; but they are so far positive, that they lead me to believe we shall at no distant date be able to confirm or refute what Prof. Lodge seems to regard as determined already.

I have already said that I am not able to completely follow some of the reasoning having reference to the alternative path experiment, but I resist the temptation to say why I do so, because after all I should be expressing only my own views, and I do not set a high value on the views of anyone (certainly not my own), unless they are backed by conclusive experiments, or harmonise with what we consider we really know. We can only reason from the known to the unknown, and in my own case, whatever scientific success I have been permitted to accomplish during the 56 years I have lived, I attribute solely to an early recognition of the harmony and parallelism which, as far as I can see, runs through all the phenomena of nature, and the simple fact which stares everyone in the face that be it a stream of people or a stream of water, the motion is observed to be more rapid in the centre would, if it stood alone by itself, be, in my opinion, an all sufficient reason for not believing that the flow of an electric current through a conductor commenced on the outside, and gradually penetrated to the interior, unless it was determined by absolutely conclusive experiments.

Although Prof. Lodge has apparently convinced himself that electrical energy is not transmitted in a similar way to that of force through a pipe; nevertheless, when suggesting an explanation of the obstruction offered by good conductors to a sudden rush of electricity, he falls back upon a hydraulic simile.

The conductor forming the alternative path seems to me to somewhat resemble the musical wires which develop the lower notes of a pianoforte; these wires are in a state of tension, and would vibrate when struck at a rate that produces a comparatively high note, but being surrounded with spiral rings of heavier wire, the inertia which has to be overcome reduces the rate of vibration, and hence a lower note is given out.

When charging the jars in the alternative path experiment nearly the whole of the induction takes place between the inner and outer coatings of the Leyden jars at the earlier stage of charging, but as the charging proceeds, the induction which occurs through the air space of the A balls, and through the alternative path, increases; and as it is the air space separating the A balls where, practically speaking, the whole, or, perhaps, I should say, nearly the whole of the resistance occurs, the difference of potential is proportionately greater between the two A balls than at the two ends of the alternative path conductor, resembling, in this respect, a telegraph line of great resistance, in which the earth forms one half of the circuit. Now when the electrical potential becomes great enough to break down the resistance opposing discharge, the spiral rings of magnetism which are formed by the passage of the electric current through the wire, and which possess inertia, check the rate of the electrical pulsation much in the same way as the spiral metal rings surrounding a musical wire, and as the electricity set in motion refuses to wait, the air space separating the B balls,

when not too far apart, opposes less resistance than the metallic conductor forming the alternative path.

I feel sure Prof. Lodge would admit that further explanation is required to account for what was observed in his recorded experiments. Assuming, for example, that electricity commences to flow on the outside of conductors, why should not the current run down the outside of a copper wire as readily as outside an iron one; and why should copper wires of varying sectional area obstruct approximately equally, and also iron wires of different sectional area do the same? I myself am disposed to think that had the alternative path conductors been thickly coated with a good insulator the results obtained would have been found to be different from those recorded.

Let us now assume the hydraulic view of the transmission of electrical energy to be the more correct one. A suspended conductor may then be regarded as a U-pipe full of water. What would happen if water in a rapid state of motion be propelled against one of the mouths of this U-pipe. The inertia of the stationary water would effectually prevent sudden transmission through the pipe, and the consequence would be that the potential of the propelled water at the point of impact would be increased in a similar manner to what occurs in a water ram, or what is observed when a hard metal block is struck by an equally hard hammer; the force developed in an infinitely small space would be infinitely great, and the propelled water would either rebound or scatter itself horizontally.

Now I am disposed to believe we have here an explanation of what was observed in the alternative path experiments. When discharge occurs something must give way, and if the B balls be separated beyond a certain distance, the discharge cannot occur in their immediate neighbourhood, and as the conductor forming the alternative path, as a consequence of its magnetic inertia, opposes so great a resistance to longitudinal transmission, lateral discharge in a greater or less degree occurs in the air space separating either sides of the alternative path conductor, and also in some degree from it to the walls of the room; and I venture to think if the experiments recorded had been performed in a darkened room, luminous stars would have been observed on the surface of the loop conductor at the moment of discharge, and chiefly at the positive end of the loop.

What I now suggest affords, I think, an intelligible explanation of what was actually observed; the B spark is in all cases produced as a consequence of the magnetic inertia of the alternative path conductor, and if such conductor be an iron one, possessing greater inertia than copper, then the tendency for lateral sparks from such conductor will be greater, and the finer the wire the more readily will lateral discharge occur between the alternative path and the walls of the room. In fact, there would be created a third or C space through which part of the electrical energy dissipates itself, and it must not be overlooked that the walls of the room under such conditions become the two coatings of a Leyden arrangement, and by permitting the accumulation of a statical charge introduce the element of time.

(To be concluded.)

THE NEW CENTRAL TELEPHONE EXCHANGE IN MANCHESTER.

AFTER the annual general meeting of the Lancashire and Cheshire Telephonic Exchange Company, Limited, on Tuesday morning last, there was held a public opening of the new operating room in the Manchester Royal Exchange, where the directors received a number of shareholders and others to view the novel and ingenious apparatus recently installed for connecting the wires of subscribers.

The company has long held an occupation of a certain portion of the upper part of the Royal Exchange, Manchester, for the purpose of a switch-room, and

when it was determined some time since to adopt what is looked upon as the best system extant, viz., the Western Electric Company's multiple switchboard, it was also decided, instead of, as at first proposed, fitting this up in their three exchanges, to dispense with two centres, and concentrate all into the large room in the Royal Exchange, already in their occupation. This room, as now altered, is 120 feet long by 24 feet wide, is well ventilated, and, when necessary, heated with hot water pipes. A new roof, partly glazed, 20 feet in height, has been added, with a view to exceptional lighting capabilities.

The concentration of the company's system was known to be excessively costly, especially in regard to the outside wires, as may be imagined, from the fact that a large proportion of the lines, within a radius of about a mile, have had to be altered so as to divert them to the new centre, and in consequence of the crowded state of the routes, these wires have had to be brought to the centre in the shape of costly cables, specially made in order to keep down the inductive effects. For the carrying of these, new poles and standards had to be erected in all directions. One result of this change, however, is very apparent, and that is the better appearance of the streets; instead of the network of wires overhead, rendered dangerous in snowstorms, neat and compact cables containing many wires cross the streets almost unnoticed.

We may state at once that the concentration offers very great advantages in regard to the efficiency of working. The trouble, annoyance, and delay formerly occasioned by the use of three centres, have now been overcome, and we learn that the subscribers are not only well satisfied with the change, but express themselves gratified with the rapidity with which their calls are attended to, and connections with other subscribers made.

The "multiple" switchboard has many advantages over the boards formerly used, an especial one being in the saving of time required to complete a connection between any two subscribers, which is mostly owing to the fact that whereas with the old board very few connections could be completed without the aid of more than one operator (the number employed in making a single connection between two subscribers often amounting to as many as six), with the multiple board all the connections are completed by the operator receiving the original call without moving from her position. With the multiple board a large increase in wire is required, as it is necessary that every subscriber's line shall be connected separately to every table or section of the switchboard in the room.

The new tables are nine in number, each fitted to accommodate 200 subscribers, by having that number of electric drop shutters, which in falling expose the number of the subscriber desiring attention. Each table is furnished with 1,600 connections to these and other subscribers, in the shape of what are called "spring jacks," arranged in groups of 600 each on the front face of the table. Any two of these "jacks" may be connected together by one of the forty-five pairs of connecting cords and plugs fitted to each table (these are kept in a tidy position by means of pulleys and weights underneath the table). To each pair a switch is allotted, by means of which the operator's telephone can be connected to any pair at will. Each pair has also connected to it a "ring-off indicator," which is operated by means of the black button with which each subscriber's instrument at his office is furnished, in addition to the ordinary white one, with which he rings up the exchange or the subscriber he is connected with. This "ring-off" system is, and has been for a long time past, a special feature of the Manchester exchange, and bridges over many of the difficulties met with in other exchanges. It is the invention of Mr. J. Poole, the company's electrician.

Three operators are employed to work each of the tables, and they are provided with revolving and adjustable chairs for greater ease and quickness of movement. The transmitters in front of them are suspended by cords, which passing over pulleys, are

balanced behind the board by weights, so that they can be placed at any elevation, or easily removed out of the way.

From the points where the various outside wires and cables terminate on the roof of the building, leading-in wires are brought into the switch-room to the "test room," placed on one side of the room and at the end of the switchboard, where they are connected to a new arrangement of test, and to what is called a "cross connecting board," which is new to England, and of an improved form devised by Mr. Poole, by means of which tests of faulty lines can be made with the greatest ease and speed without disturbing a single wire, and by which the lines can be run and kept in a perfectly straight and regular manner, and all confusion and faults consequent upon tangled wires avoided. On the test board are fitted earth strips for lightning arresters of the serrated type usually seen in telephone transmitters; to one end of a spring fixed to a serrated piece opposite the earth plate is attached the line wire; the opposite end of the spring is in contact with a fixed metallic piece, from which a wire goes to the cross connecting board where the cable wire to the table is connected. The object of the spring connection is to facilitate testing without unscrewing wires and causing delay; a small metal wedge (insulated on one side), connected with a wire leading to a telephone, is inserted between the spring and the metal piece, and a test can be taken, according to the way in which the wedge is inserted, of the circuit outwards through the line, or inwards through the switchboard, &c. At the same time, by the removal of a plug, the earth connection of the lightning arrester can be broken, and the direction of any "ground" fault at once be determined. By means of a double faced wedge, the telephone can be placed in circuit.

From the cross-connecting board each wire proceeds in a cable, and is connected to its own number at every table. The cables containing these consist of 43 wires, and they are arranged in a new manner not before used in this country, by means of which they are kept much tidier, and only about one-half the length is used as was formerly required, but a further reduction in this length has been made by a new method of connection devised by Mr. Poole. It will be interesting to know that upwards of 100 miles of wire is in use behind the switchboards in coupling up the different parts of the boards, and some 65,000 soldered connections have been made in jointing this amount of wire.

Special arrangements have been made for the smooth and quick working of the long-distance trunk lines, which form such an important feature of the company's system. Tables for the working of these are arranged at right angles to the ordinary ones, to which the wires are brought in sets of ten, each set worked by one operator, who has to display much care and attention on their proper working. Another table is arranged near these, where an operator is kept exclusively for writing out the tickets for these trunk calls, which are afterwards stamped with an automatic time stamp, showing the time to a minute, and handed to the trunk operator to be put through in their order.

The operations in connection with this transfer have been in progress for some considerable time, and it may be imagined that the substitution of multiple cables for single wires must of necessity have consumed a large amount of time, especially when required to be manufactured to specified lengths. These multiple cables consisted of 50 well insulated wires provided with means for neutralising induction. A considerable mileage of these "anti-induction" cables have been manufactured for this work by Messrs. Walter T. Glover & Co., of Salford, and we are informed that many advantages are experienced from using them, and that great freedom from "cross-talk" has been noticed. The changing of the wires on the external circuits was a matter of some difficulty, but was successfully accomplished, and the old centres were cut out and the new switchboard brought at once into successful use.

The difficulties in connection with the erection of

the new switchboard and the altered electrical arrangements have been very great indeed; but the constant supervision of Mr. Poole, the company's electrician, his untiring energy, and the many useful improvements and clever combinations he has introduced into the apparatus, have brought about so complete and successful a result that the company can congratulate itself that it has in the Manchester system a switch room equal, if not superior, to any in existence.

TWO OPINIONS—WHICH IS CORRECT?

"THE copper statistics for August must be gall and wormwood to the Copper Ring; showing, as they do, that with all Secretan's millions and all Secretan's men the copper trade will not and cannot be either bullied or cajoled into surrendering to the French speculators. The French gamblers can hamper English trade—they are doing that effectively; they can, by means of their conspiracy, drive hundreds of English workmen out of employment and doom hundreds of English families to starvation, but they cannot force the copper trade to surrender. There can be no doubt what the end of all this must be. The only question is how long the French *clique* can put off the inevitable crash. Meanwhile, the manufacturers, although they will not buy M. Secretan's copper at M. Secretan's price, manage to get what they require for their most pressing needs in the shape of old copper. In some directions copper is going out of use altogether, many of the railway companies, for instance, substituting steel tubes for brass and steel linings for copper, as we predicted some weeks ago that they would. Substitutes for copper are being eagerly sought and readily adopted. And this sort of thing is likely to go on until the Copper Ring bursts or breaks down under the weight beneath which it is staggering."—*Financial News*.

"IF only a part of all that has been both said and written in reference to the copper boom were true, its bottom would have been knocked out long ago, but instead of there being any signs of this occurring, the 'ring' appears stronger than ever, and more able and determined to carry their operations to a successful issue than even when they secured their early triumphs. Unless some untoward event occurs there appears every probability that prices will be upheld to the time stipulated in the contracts the syndicate have made with the big mining companies of the world.

Whether the Paris ring will eventually make a big financial success is an open question, but this much can be taken for absolute certainty, and that is they are far too deeply in the mire to be able to allow their operations to collapse. By going on to the end they may score a triumph which will be unprecedented in the history of the world; by now stopping they would lose a sum of money that can only be estimated by millions. Whether, therefore, for good or for ill, there can be little doubt that unless there is some violent disturbance in the financial world, the price of copper will be kept up to something like its present quotation."—*Financial Times*.

RHOADS'S ELECTRIC ARC LAMP.

THE object of this invention is to construct electric lamps which are more compact and occupy considerably less compass than the lamps now in use, and to provide an improved feed and arc striking apparatus, with the employment of a curved carbon and special means of using the same.

The carbons are fixed in their holders in a horizontal position, and fed in opposite directions by toothed wheels and an intermediate pinion wheel between them; the shunt coils feed the lamp by means of ratchets and

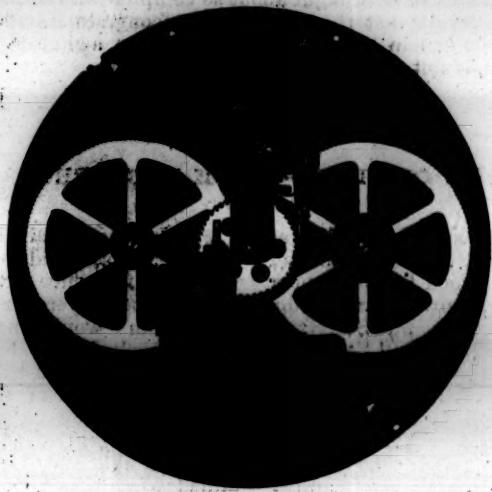


FIG. 1.—PLAN.

a wheel, and the arc of the lamp is struck by means of an angular or helical slot in a bush mounted on the escape wheel axle. In the axle is a pin which works in the helical slot, the upper part of the bush rests in the

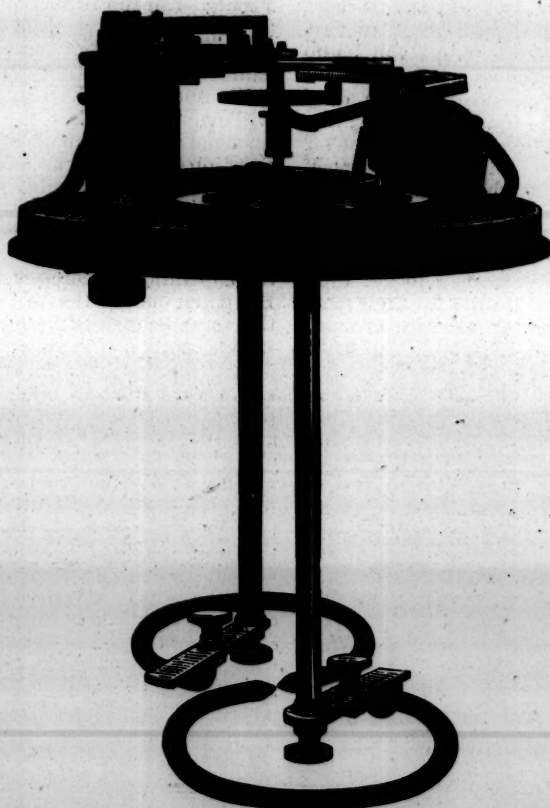


FIG. 2.—ELEVATION.

fork of the main coil armature, and a spring acts on the end of the fork to throw it down when the current is off. There is also a stationary tooth or catch mounted to gear into the ratchet wheel on the bush, so that in its sliding up and down action it closes and opens the carbon points. When the current is on the upward

motion opens the points, the forked armature being worked by the current in the main circuit.

We have illustrated and briefly alluded to the lamp of Mr. Rhoads because it shows great ingenuity in the working out of its component parts, but we doubt whether there is any market for an apparatus so comparatively complicated, the tendency of the present day being to employ regulators of a more simple character. Curved carbons, moreover, are expensive and more difficult to manufacture than straight ones, and this would form a serious item in the expenses of a large arc light plant.

It will be within the memory of our readers that circular carbons were used in almost every conceivable manner in Heinrichs' lamps, but we do not think that he hit upon the particular arrangement adopted by Mr. Rhoads. But however this may be we understand that the Heinrichs' patent to which we refer has lapsed, so it is a matter of no consequence.

It is needless to point out that the employment of a lamp of this kind eliminates shadows and enables a very long feed of carbons to be brought within a small space; all the advantages and disadvantages are apparent to experts in arc lighting, so we need only say that Mr. Rhoads, who we feel sure will one day accomplish something of greater practical and commercial utility in the field of invention, will supply any further particulars of his lamp for the asking.

NOTES.

Electric Lighting in Barnet.—On Saturday night the streets of Barnet were lighted by electricity, and the novelty excited unusual interest among the townsfolk. For some years the Barnet Local Board has complained of the high price which they have been called upon to pay for the gas supplied to the public lamps by the Barnet District Gas and Water Company, and has had under consideration the question of lighting by oil or other means. A few months ago, though the price per thousand cubic feet of gas had gradually been reduced from 6s. to 4s. 6d., they entered into negotiations with Mr. H. F. Joel for the lighting of the town by electricity. The gas company then reduced their price to 4s. 3d., but in the result Mr. Joel's offer was accepted, and a three years' contract entered into. A company was formed by Mr. Joel, and on Saturday (the gas contract having expired on Friday) they entered upon the three years' contract, and lighted the streets for the first time. There are 71 lamps, each of which is placed on a strong but ornamental iron post 12 feet in height, and fitted with a reflector by means of which the light is distributed over a large area. The current is conducted over the town by about five miles of hard drawn copper wire. Where the wires cross main thoroughfares they are laid underground in creosoted wooden troughs, and are insulated with rubber and encased in lead tubes to protect them from mechanical injury. These underground wires pass up through the lamp columns to the globes, and each column is provided with a small door, so that, should it be required, a switch for turning off any particular lamp independently may be used. The works are at the Hadley end of High Barnet, and the company purposes laying down powerful electrical machinery for supplying from 1,000 to 5,000 lamps for use in private houses and places of worship.

Ship Lighting.—The *Alfonso XII.*, the largest merchant steamer yet built on the Tyne, has been lighted by electricity by Messrs. J. H. Holmes & Co., of Newcastle. The generating plant consists of two sets of combined engines and dynamos, each set comprising a "Castle" dynamo coupled direct to a Tangye compound vertical column engine. At 190 revolutions the dynamo gives 135 ampères and 80 volts.

Ball-Room Lighting.—In connection with the festivities at Hunley in celebration of the coming of age of the Earl of Dudley, large temporary ball and supper rooms have been erected, and these, together with the refreshment tent and other offices, have been lighted by electricity. Incandescent lamps of 16 C.P. to the number of 125 have been wired, and there are three "Sunbeams," one of 400 C.P. and two of 200 C.P. Over 400 yards of heavy main cable have been used, branching off at the end into the various tents, which are all connected by covered corridors. The current is supplied from an Elwell-Parker dynamo driven by one of Fowler's ploughing engines; storage batteries are also used to supply light after the engine has been stopped. Notwithstanding the continuous wet weather the plant has run without a hitch. The whole of the lighting arrangements were placed in the hands of the Walsall Electrical Company, and great satisfaction, and even admiration, has been expressed at the results attained.

Theatre Lighting in Berlin.—Berlin, says the *Industries'* correspondent, has been one of the first to adopt the electric light in theatres, and is still leading the way in this direction. By the middle of September, two more theatres will be fitted up with glow lamp installations, viz., the Lessing, in the Carlstrasse, and the Ludwig Barnay (formerly the Walhalla Operetten Theater), in the Charlottenstrasse. The former house has been completely rebuilt, and stone and iron are the only materials used in its construction. It will be lighted by about 1,000 glow lamps. In the latter theatre considerable structural improvements have been made, and it will receive an installation of 1,250 glow lamps, of which 750 are 25 C.P. lamps of three colours for the stage, and 500 are ordinary 16 C.P. lamps for the auditorium and offices. The installation has been erected by the company known under the abbreviated name of Allgemeine Gesellschaft. The regulator for the stage has been made by Herr Bähr, of Dresden, and Seel glow lamps are exclusively used. The following is a list of Berlin theatres either already electrically lighted, or about to be so:—

	Glow Lamps.
Königliches Opernhaus	5,000
Königliches Schauspielhaus	2,000
Deutsches Theater	1,200
Barnay Theater	1,250
Kroll's Theater	25 arcs and 300
Reichshallen	600
Friedrich Wilhelm Stadt	1,200
Lessing Theater	1,000
Residenz Theater	1,000
American Theater	200

From this list it will be seen that there will shortly be over 13,000 glow lamps in use for theatre lighting in Berlin.

Eastbourne Local Lighting Scheme.—At a meeting of the Lighting and General Purposes Committee, held August 23rd, a letter was read from the secretary to the Eastbourne Electric Light Company, stating that the directors had considered the offer of the Corporation, and come to the conclusion that they cannot supply the Parade arc lamps at less than £35 per lamp per annum. It was resolved "That this committee cannot see their way to recommend the Council to renew the contract for lighting the parades by the electric light at the rate of £35 per lamp per annum, at the expiration of present contract, the Electric Light Company having definitely refused the compromise proposed by the Council." Councillor Chambers expressed regret at reading the decision of the Electric Light Company, and said that he believed a door was still open for further negotiations. He hoped the Council would try to meet the Electric Light Company by having fewer hours lighting. Councillor Cunningham was in favour of retaining the light at any cost, and said that Brighton made a mistake in doing away with the electric light. Councillor Young agreed with Councillors Chambers and Cunningham as to the value of the electric light. On a show of hands the resolve of the committee was adopted.

Norwich and the Electric Light.—At a recent meeting of the Norwich Town Council Mr. Councillor Squirrell moved: "That a committee be formed, to be called the Lighting Committee, and that it should forthwith enquire into the cost and method of electric lighting in Brighton, Taunton, Eastbourne, Poole, Bradford, and any other towns in which electric lighting is in use, and report to the Council at its next meeting." His object in bringing this question before the Council was that they might be posted up with the fullest information as to the improvements and progress of electric lighting. Since they tried the experiment of the electric light in Norwich he believed great improvements had been made in the methods of lighting, and the Council ought to have ample information on this subject. In 20 towns in England electric lighting had been esta-

Library Lighting at Leeds.—The new scheme for lighting the Art Gallery and Museum at Leeds by electricity has been tried and proved successful. The room where the electricity was tested was that portion of the new building to be used as a reading-room, and the incandescent lamps shed a beautiful light, much superior to the lighting of the present reading-room, which forms part of the municipal buildings, and is to form a sculpture gallery and entrance to the Art Gallery in the rear. The new reading-room is to be finished first, so that it can be used while the present room is being adapted to its new purpose.

Train Lighting.—We notice that the Lancashire and Yorkshire Railway, after experimenting a little with the electric light, has adopted gas for lighting railway carriages. Most of the carriages are now lit with a patent gas, and it is claimed by the company that the light is much better and cheaper than that of oil, and more economical than electricity. It is a matter for regret that the company did not experiment much with electricity, when the conclusions at which its officials have arrived might have been modified.

Office Installations.—We note with pleasure the evident appreciation of incandescent light in offices. The demand is steadily increasing, and proprietors of most new city offices consider the electric light an essential requisite. The latest addition to the list of London office installations is Messrs. Johnson, Rudd and Johnson's in Austin Friars. The plant will consist of an Elwell-Parker dynamo, driven by a Crossley gas engine, fitted with tube ignition. The installation is in the hands of Messrs. Drake and Gorham, who are supplying 53 of their latest type cells.

Telephone in Dumfries.—The first issue of the National Telephone Company's directory of subscribers to the Dumfries and Maxwelltown exchange shows that the leading merchants, hotels, newspapers, shopkeepers, &c., have availed themselves of the advantages of telephonic communication. There are as yet only 37 names on the list, but no doubt this number will soon receive many additions. The exchange was inaugurated on the last day of August, when Mr. A. R. Bennett, the general manager for Scotland, addressed a large audience.

The Telephone in Fifeshire.—The National Telephone Company has extended its system to Cowdenheath within the last few days, and anyone desiring to speak to subscribers in Glasgow, Edinburgh, Dundee, or intermediate towns, have only to go to the grocer's shop of Mr. Dick, High Street, and pay the fee.

The Telegraph in the Western Islands.—Telegraphic communication with the islands of Coll and Tiree was opened last week. A wire is carried overland from Tobermory and Calgary, on the western side of Mull, and then by cable to Coll. An office for telegraphic business has been established at Calgary. This connection with the mainland will be of great importance to the islanders, who are highly pleased that their long-continued efforts to secure this boon have at last been realised.

Telephone Troubles Again.—The Glasgow *Evening News* of the 1st inst. has the following:—"The telephone was inaugurated at Dumfries yesterday, and wishes for its prosperity was duly drunk in various liquors. A month hence, when a Dumfries man yells "Hello" into the instrument for a quarter of an hour, and then the fair instrument-tender at the central switches him on to his parson, when he wants to make things lively to his fishmonger, the result will probably be to send that Dumfries man to drink once more and it won't be to the instrument's prosperity, either."

Street Lighting by Incandescence Lamps.—Some of the daily papers, with more valour than discretion, boldly assert that the spirited action of Barnet in the matter of street lighting is a step in the right direction, and that it needs no prophetic eye to discern that the electric light is the destined illuminant of the future. We should be glad to think that this was the case, and indeed it does not seem to be altogether improbable, so far as interior house lighting is concerned; but whoever seriously believed in the utility of lighting streets by incandescent electric lamps, unless in cases where the electrical supply is cheaper than gas, or in localities where the latter agent is not forthcoming? The experiments on the Holborn Viaduct, at Leamington, and in other situations, have shown conclusively that the incandescent lamp is out of its element, except under the circumstances just enumerated.

Dayton Electric Railway.—The first trip over the new electric road at Dayton, O., recently took place at midnight. The cars passed down Main Street smoothly at a rapid rate, and Mr. Morris, of the Van Depoele Company, then rang the gong lustily. The residents of Riverdale were awakened and were soon out. Great excitement and cheering prevailed. The cars made eight miles an hour most of the way, but for short stretches ran at a 10 mile rate, and are capable of doing 12 miles an hour. Mr. Morris wrote to the *Western Electrician*: "I am running 10 cars now and everything tip-top, with all new men who never saw an electric car before."

The Heisler System.—The Heisler Electric Company has secured patents in Belgium, England and Italy for its system of lighting, and is expecting the same favour to be accorded it in Germany and Austria at an early date, when work in the foreign field will be at once begun.

Central Institution for Technical Education.—The Session of the Central Institution of the City and Guilds of London Institute will commence on October 2nd. The Clothworkers, Siemens', Mitchell and Institutes Scholarships will be competed for at an examination held on September 25th to 28th. The courses of instruction include lectures on mathematics, engineering, chemistry and physics, and laboratory and workshop practice.

Thomson-Houston Dynamo Patents.—In a recent action for infringement of the Thomson-Houston dynamo patent, in which the defence was anticipation by a previous patent of the same inventors, Judge Colt, giving judgment, said: "Upon the subject of infringement I have no doubt. The question is not as to the form of dynamo the defendants may use, or whether their machine may be adjusted by hand to avoid sparking, but the question is whether they use the complainant's invention by the employment of substantially the same means to accomplish the same result, namely, the regulation of the current by means of a device responding to changes in the main or generated current, and this the complainants have shown."

Price of Copper Wire.—Messrs. Frederick Smith and Co. inform us that their price for high-conductivity copper wire has been advanced $\frac{1}{4}$ d. per lb., making the present basis price of 0 to 20, 11d. per lb.

Efficiency of Dynamos.—John Farmer, an electrician in the employ of the St. Louis Western Electric Light Company, is said to have designed and to be building a dynamo of the Gramme ring type, which utilises over 90 per cent. of the wire on the armature. What on earth does Mr. Farmer do with the other 10 per cent?

Firing Small Arms by Electricity.—It is stated that the German authorities are trying a new system by which rifles may be fired by electricity, thus doing away with the difficulty which arises from the non-ignition of the ordinary cap, which depends for its explosion on the ignition of the fulminate it contains. The firing by electricity will, of course, allow of a very light "pull off," which in itself should be a great argument in favour of the new system.

The Use of Cut-Outs.—The simultaneous burning out of twenty-three electric clocks in Boston, presumably by crossing the circuit with an electric light wire, indicates, says *Modern Light and Heat*, that fusible cut-outs are as necessary with this particular electrical apparatus as with any other.

Lecture.—A lecture on electricity was delivered by Mr. J. Jerritt, A.S.T.E., to a large and select audience at Axminster on Wednesday, August 29th, in aid of the funds of the Cottage Hospital. The chair was taken by the vicar, the Rev. A. Newman, M.A., who, in proposing a vote of thanks to Mr. Jerritt, complimented him on his very successful and interesting experiments. A sum of £10 will be handed over to the treasurer of the hospital.

Rival Petroleum Motors.—A discussion has been proceeding in the columns of *Invention* on the relative efficiency of the Spiel and the Priestman petroleum engines, and it has been claimed that the consumption of oil by the latter is 60 per cent. greater than that of the Spiel. An important fact, which has not yet been brought out in the discussion, is that Messrs. Priestman have succeeded in using a non-dangerous oil. With the oil used with the Spiel engine, the Priestman would show results equal to those of its rival; but the safety of working is a vital point, and Messrs. Priestman have accomplished what we are given to understand the owners of the Spiel engine have tried in vain to do.

One Way of Doing Business.—It is announced that one company has secured the American patents for both Edison's phonograph and the Tainter-Bell graphophone, and that the business is to be conducted after the method of the American Bell Telephone Company. That is to say, sub-companies will be licensed by the parent company in different parts of the country, and the instruments will not be sold outright, but will be rented at \$40 each per annum. This is curious to say the least. There are conceivable reasons why the telephone should be leased only, but there are none, so far as we can see, for a similar practice with regard to the phonograph or graphophone. It may be that there is a field for the "talking machine," but this is surely not the best plan for cultivating it. If similar tactics are adopted with the instruments in this country, we fancy but very little business will be done, for they can be made cheaply enough to be sold outright at a very moderate figure.

"Dynamo-Electric Machinery."—*Errata.*—P. 570, line 9, for *forward*, read *backward*; p. 570, line 11, for *backward*, read *forward*; p. 640, line 6, for *excitation*, read *saturation*.

City of London College.—The Michaelmas session of the evening classes in connection with this institution commences on Monday, October 1st, and, judging from the very extensive syllabus which we have received, the lectures in the engineering department, presided over by Mr. Henry Adams, should be of the utmost service to the students.

Good Men and True.—A new floating light has been placed off the Gabbard Sands, and the *Times*, in an article upon the subject, thus speaks of the excellent qualifications of the men in charge of lightships: "It may be mentioned, indeed, as a proof of the capital material of which lightships' crews are composed that recently, when the electric telegraph cable connecting the Sunk Lightvessel with Walton-on-the-Naze was handed over by the Telegraph Construction and Maintenance Company, who had been carrying out the experiment, to the Trinity House, ordinary lightmen took up the entire work of maintaining communication, including the repair of the cable, and have executed the task in such a way as to excite both the astonishment and approval of the Postal Telegraph authorities."

The British Association Presidential Address.—Sir Frederick Bramwell's address, according to the Leader in yesterday's *Standard*, seems to have been principally directed towards showing that the civil engineer possesses, or should possess, the attributes of a poet, and he was therefore correct in assuming that he was mainly discoursing upon "Next to nothing."

Special Telephones.—We have just seen two very beautifully got up Gower-Bell telephones, manufactured by the Consolidated Telephone Company, for their Majesties the King and Queen of Portugal. They have been designed so as to harmonise with the furniture in the Royal Palace, and they present so many points of interest that we shall endeavour to give details of their construction and character in our next issue.

Personal.—We learn that Mr. James Swinburne has left Messrs. Crompton & Co.'s service, and is now established in practice at Chelmsford as a consulting electrical engineer. Mr. Swinburne's varied abilities and great special knowledge, qualities which must have made him a valuable assistant to Messrs. Crompton & Co., will no doubt secure him a full sufficiency of business in his new avocation, in which we heartily wish him every success.

Mr. Henry C. Davis, president of the New York Electric Club, was entertained at dinner upon his return to America, after a sojourn of nearly two months in London and the Continent. A portrait of the genial president appears in the last issue to hand of *Modern Light and Heat*, and a very excellent likeness it is.

The "Days with Celebrities," which appear weekly in *Moonshine*, is devoted in the issue of the 8th inst. to Mr. Edison. Naturally Colonel Gouraud figures as his *Fidus Achates*.

Messrs. Woodhouse and Rawson in particular, and electrical firms generally, have a doughty champion in Mr. George Offor, who has been showing the representative of the Nott's *Daily Express* a very glowing prospect of the progress of electric lighting. The local journalist has come to the conclusion, after having the benefit of Mr. Offor's explanation, that electric lighting for towns is a thoroughly practicable and probably impending innovation.

Extension of Business.—We learn that the Acme Electric Works, of Finsbury, has been so successful under the management of Mr. A. C. Cockburn and Mr. F. Day, that they have been compelled to remove to much larger and commodious premises at Ferdinand Street, Chalk Farm Road. We understand that the main shops are three floors each, of 110 feet long by 23 feet broad, and other outside shops, and that there is much room for future extension. The total floor space at present is upward of 10,000 square feet.

Lightning Dischargers Essential.—Lightning struck the overhead conductor of the Frankfort Offenbach Electric Railway the other day. The current was led by the leads to the central station house, where it destroyed the armature of the dynamo connected to the circuit.

Enterprise at Helsby.—The Telegraph Manufacturing Company has just completed another large addition to the already extensive factory. This is for the special work attached to vulcanised electric light leads, which the company can now supply to any possible specification. Extra lighting plant has also been added, making an installation of over 500 incandescent lamps for lighting the shops alone. Another batch of cottages is also approaching completion, when nearly all the company's employees will be comfortably housed within a few yards of the works. A large workmen's dining hall and reading room, capable of seating over 200 persons, has also been provided; and other extensions are contemplated. The company is full up with orders, and one department is running night and day.

Taylor, Taylor and Hobson.—Messrs. T. S. and W. Taylor, manufacturers of optical electrical and scientific apparatus, of Slate Street, Leicester, notify that in future the style of the firm will be altered to Taylor, Taylor, and Hobson. We understand that the machine for engraving, dividing, forming, &c., which was lately introduced by the firm, has been a great success, and that a rapidly-extending business has necessitated extensive additions to their premises.

Carrying Capacity of Conductors.—A correspondent in our issue for August 24th, asked a question respecting the size of wire necessary to carry a 10 ampere current in a dynamo armature. Nobody having replied to his query, we make bold to assure him that the gauge of wire he mentioned would be ample for his purpose.

Lightning.—We should think that in consequence of the abnormally large number of people who have this year been either killed or seriously injured by lightning, the subject will receive greater attention than has ever been the case since the time of Franklin's famous experiments. Dr. Oliver Lodge has already done much to pave the way; Mr. S. A. Varley is ably backing him up, and the discussion which is to take place at the British Association meeting should be the means of effectually bringing the phenomena of lightning into the prominence which such an important and dangerous agent demands. The need of protecting human life from lightning strokes is far greater than that of securing to the public immunity from dangerous electric light currents, which is a matter easy to accomplish.

Patents for Current Regulation.—The following is a copy of cablegram just received from the Thomson-Houston International Electric Company, by Messrs. Laing, Wharton and Down, and which refers to our note of the 17th ult.:—"Judges order restricting American Co. from sale or shipment, granted yesterday."

Lead Covered Cables.—In our issue of July 27th we gave a report by Mr. Sunny, of Chicago, on underground electric light conductors. We remarked also that the report would probably give some encouragement to makers of lead covered cables. It is not, of course, to be assumed that because one make of lead covered cable is good all are good. We have, however, ascertained that the cable Mr. Sunny is using, and to which he referred as giving such satisfactory results is the Patterson patent cable made by the Western Electric Company.

Electric Light Maintenance.—Mr. John H. Storr, of Westgate-on-Sea, writes to us respecting the calculations in an article translated from the German, and we are much obliged to him for drawing attention to the errors: "I am sorry to see a very serious error has crept into the calculations of the cost of maintenance of the electric light on page 233 of your last journal. If you will refer to the second set of calculations you will see that 5 per cent. put on £1,495 (cost of engines) is only £74 15s., not £746 5s., and then, instead of totalling up to £12,496 5s., is only £1,249 15s. The addition of the first set of figures is also wrong."

To Electric Light Contractors.—At a meeting of the shareholders of the Lynton and Lynmouth Hotel and Property Company, held on the 3rd inst., the chairman said:—"The electric light had had their careful consideration, with the result that tenders would shortly be issued for the installation."

Cable Repair.—It is now announced that the second cable of the Indian Government, broken between Bushire and Jask on the 13th of August, in the Persian Gulf, was restored on the 1st inst., duplicate communication being thus restored with Australia, China, India, &c., by the Indo-European line. The delay of existing messages during the breakage has been entirely worked off.

A Hundred Years Hence.—A would-be prophet, in a forecast of what England will be a hundred years hence, predicts, *inter alia*, that all mines, public buildings, and houses will be illumined by electric light; that trains, omnibuses, and trams will be propelled by electricity; and that all electric wires will be placed underground. He also prophesies that Liverpool and New York will be connected by telephone; that Ireland and France will be connected by tunnels and bridges; and that there will be a continuous railway from London to Pekin, through Siberia. Well, it will be all the same to us, anyhow, whatever happens a hundred years hence.

The Electric Light in Bath.—The special Electric Lighting Committee held another meeting last week. Several meetings have been held, and the arrangements for the introduction of the electric light into Bath are progressing satisfactorily.

A Chance for Inventors.—Sir Edward Watkin, it is said, intends offering a prize of 100 guineas for the best solution of the problem of telephoning on trains between passenger and driver, or between passenger and guard.

The "Corner" in Copper.—The *Daily News* City article of Wednesday makes it appear that Chili bars are likely to keep up their high price for some months to come, and that the "corner" is therefore still victorious.

Theatre Lighting in Vienna.—The New Hofburg Theatre, in Vienna, was lighted up by electricity on Friday last. There are over 5,000 lamps in the house, ranging from 10 to 40 candle-power, and the electrical supply is on what Mr. Crompton would call the battery transformer system.

Thursday's Proceedings in Bath.—The following telegram reached us as we were going to press:—
Presidential Addresses in Sections A and G both of strong electrical interest. Prof. Fitzgerald contributed a review which Sir Wm. Thomson described as a sparkling literary effort of past and present theories and experiments respecting the inter-relations of electricity and magnetism. The most important electrical paper in Section A was one by Professor Stroude and Mr. Haldane Gee, on electro-calorimetry, describing a new instrument which was characterised as a great advance in the means of measuring specific heats. Mr. J. Brown read a paper on figures produced by electric action on photographic dry plates, Mr. Lant Carpenter one on a comparison of Gassner's dry cells with Leclanché's, and Sir William Thomson communicated the results of some experiments on the magnetisation of soft iron bars of different lengths in a uniform field. Mr. Preece's address in mechanical section was well received. The section room was crowded during the reading of papers by Col. Gouraud and Mr. Edmunds on the phonograph and graphophone respectively, and the utmost interest was shown in both instances.

Electric Search Lights for War Purposes.—The German military authorities have made some interesting experiments in night attack with the aid of the electric light. The plant used consisted of an 18 H.P. portable steam engine, carrying a dynamo and search lamp. The novelty of the experiment consisted in using the beam of light, not direct, but as reflected from a second mirror, placed about 200 yards distant from the lamp, so that the enemy should remain in ignorance of the exact position of the electric lighting plant itself. The projector is fitted with an electromotor, by which it may be set to any desired angle, the current being supplied by two cables from the dynamo, whereby the movement of the projector is controlled.

NEW COMPANY REGISTERED.

John Harper and Company, Limited.—Capital £20,000, in £10 shares. Objects: To carry on business as malleable iron and brass founders, hardware manufacturers, and as mechanical and electrical engineers. An agreement of 27th ult. is to be adopted. Signatories (with 1 share each), *John Harper, *F. W. Harper, C. H. Harper, and Eliza Clarissa Harper, all of Bilston; W. H. Thompson, Willenhall; *James Slater and S. M. Slater, of Darlaston. Directing qualification, £250 in shares or stock of the company. The signatories denoted by an asterisk are the first directors. The company, in general meeting, will determine the remuneration of the board, but £200 per annum is to be the minimum. Registered office, Walsall Road, Willenhall, Stafford. Registered 3rd inst. by R. Jordan, stationer, of 120, Chancery Lane.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Barnet and District Electric Supply Company, Limited.—An agreement of July 27th, filed on the 25th ult., between H. F. Joel, of 31, Wilson Street, Finsbury, and Walter Blawell, of 5, Copthall Buildings, provides for the purchase by the company of the interest of Mr. Joel in premises at Barnet, for the purpose of an electric lighting station, with plant, machinery, &c., and also his interest in an agreement for carrying out a system of lighting within the district of the Barnet Local Board. The purchase consideration is 100 fully paid founders' shares.

Rees's Miners' Patent Safety Electric Lamp Company, Limited.—Under a contract of the 27th ult., between John Price Rees and T. M. Field, the former agrees to sell the company his present and future patent rights and improvements for £30,000 in fully paid shares and £10,000 cash.

Macmahon's Electric Automatic Registering Company, Limited.—An agreement made July 16th and filed on the following day provides for the allotment of 19,500 fully paid shares to Mr. F. E. Macmahon, of 2, Prince's Buildings, Victoria Street, in accordance with the purchase agreement dated February 15th, 1888.

Petroleum Engine Company, Limited.—The statutory return of this company, made up to August 1st, was filed on the 13th ult. The nominal capital is £100,000, in 20,000 shares of £5 each; 17,471 shares have been taken up, and of these 17,464 are considered to be fully paid up. The calls unpaid amount to £35. Registered office, 20, King's Arms Yard.

Bedford Electric Light Company, Limited.—The registered office of this company is at 3, St. Paul's Square, Bedford.

Chelsea Electricity Supply Company, Limited.—The registered office of this company is situate at 37, Sloane Square, Chelsea.

CITY NOTES, REPORTS, MEETINGS, &c.

Lancashire and Cheshire Telephonic Exchange
Company, Limited.

The report of the directors for the year ending 30th June, 1888, states that the subscriptions and rentals (including those of the out-districts) pertaining to the financial year, amount to £89,797 5s. 10d., as compared with £82,490 14s. 6d. for the year ending 30th June, 1887. The amount of income carried forward to next year's revenue, as representing sums received in advance for periods extending beyond 30th June, 1888, is £40,377 3s. 5d., against £38,276 17s. 4d. in previous year's balance sheet. On the past year's working the profit is £32,466 8s. 7d., which, with a credit balance of £1,496 14s. 1d. remaining from previous account, makes a total fund of £33,963 2s. 8d. After deducting from this sum bank interest, interest on reserve fund, and the interest dividend declared in February last, there remains a balance of £19,430 15s. 10d. The directors now recommend a further dividend at the same rate as in February, making a complete dividend of 7 per cent. for the year ending 30th June, 1888, which will absorb £14,000, and leave a balance of £5,430 15s. 10d. The directors propose that £3,000 of this shall be placed to the reserve fund (making a total reserve, including interest, of £8,850); and that the remaining £2,430 15s. 10d. be carried forward. The total number of subscribers on 30th June, 1887, to the various "exchanges," was 3,788, and of private renters, 1,347; this year, at the corresponding period, the figures were 4,103 and 1,430 respectively. In last report it was stated that the directors would shortly bring into operation in Manchester a new switching apparatus, similar to the one that has answered so well in Liverpool. The installation of the new switchboard in Manchester has since been completed, and the directors are quite satisfied with the results. As opportunity offers, the new system will be introduced in other large towns of the company's district, commencing about October with Blackburn.

Manchester Edison-Swan Company, Limited.

The sixth ordinary general meeting of this company was held, Monday 3rd, at the Memorial Hall. In the absence of Mr. V. K. Armitage, chairman of the company, Sir J. C. Lee took the chair. Mr. John E. Sharpley, the secretary, read the directors' report.

In moving the adoption of the report, the chairman said that in accordance with the decision arrived at in September last the capital of the company had been reduced by one pound per share. The money had actually been lost, and it was thought well, as explained by the chairman a year ago, to look the circumstances boldly in the face, and write off the necessary amount; so that now the figures in the balance-sheet only represented actual values, except, of course, the £13,000 paid for patent rights, the present value of which is difficult to determine. The report in the hands of the shareholders showed a balance of £1,781 15s. 3d. in favour of the company. Out of that balance it was proposed to pay a dividend of 5 per cent., which would absorb about £1,000, to place £500 to reserve fund, and to carry forward £281 15s. 3d. to the next account. The orders received during the year would have been more numerous than they had been but for the difficulty in carrying the wires either over or under the streets. If the Corporation gave them permission to cross the streets, business could be done on much more advantageous terms than at present.

Mr. J. R. Williamson, who seconded the motion, said that the Act of 1882, instead of facilitating the progress of the electric light, as it was intended to do, had done the very reverse. The electric lighting companies had had their hands tied ever since. During the present year, however, action had been taken with the result that the objectionable clauses had been altered, and no doubt a great impetus would be given to electric lighting. Large lighting stations would be established all over the country within a few years, and he expected the company would participate in much of this work. He was glad to say that the business done showed an improvement over that of any previous year, and, further, as the expenses of the company had been reduced, the result was so far satisfactory that the directors recommended a dividend of 5 per cent.

Mr. N. Sheldermine said that in view of the probable increase in the business of the company, he thought it was desirable to keep their ready money and trade with it rather than declare a dividend.

The Chairman replied that the directors had very carefully considered the matter, and they thought the shareholders should share in any advantages that had been gained by careful trading. There was now every prospect of the company becoming a dividend-paying company.

The motion was then put to the meeting, and the report and balance sheet adopted and approved.

On the motion of the Chairman, seconded by Mr. Grimshaw, a dividend of 5 per cent. was declared, and it was resolved to use the remainder of the balance in the manner recommended by the directors.

On the motion of the Chairman, seconded by Mr. Ernest Crewdon, Mr. Edward Cross was re-elected a director, and the appointment of Mr. J. R. Williamson as managing director was confirmed. The auditors were re-elected, and a vote of thanks was accorded to the directors for their past services.

TRAFFIC RECEIPTS.

The Cuba Submarine Telegraph Company, Limited. The number of messages passing over the lines of this company during the month of August was 1,257, estimated to produce £2,500, against 1,250 messages, producing £2,500 in the corresponding month of last year. The receipts for the month of May, estimated at £2,500, realised £2,507.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending August 31st, 1888, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £2,501.

The West India and Panama Telegraph Company, Limited. The estimated receipts for the half-month ended the 31st August are £2,500, as compared with £2,500 in the corresponding period of 1887. The May receipts, estimated at £2,500, realised £2,500.

The Great Northern Telegraph Company, Limited. The receipts for August, 1888, £23,300; January 1st to 31st August, 1888, £170,200; corresponding months, 1887, £174,100; and of 1886, £169,900.

The Direct Spanish Telegraph Company, Limited. The estimated receipts for the month of August were £1,514, against £1,514 in the corresponding period of last year.

The Eastern Extension, Australasia and China Telegraph Company, Limited. The receipts for the month of August, 1888, amounted to £2,500, compared with £2,574 in the corresponding period of 1887, or an increase of £1,500.

The Eastern Telegraph Company, Limited. The receipts for August, 1888, amounted to £24,700, compared with £24,000 in the corresponding month last year, or an increase of £700.

The West Coast of America Telegraph Company, Limited. The gross earnings for the month ending August 31st are £2,500.

CORRESPONDENCE.

Lightning.

With respect to the criticism which Mr. S. A. Varley does me the honour to make under the above heading in your last issue (page 224) on my articles in *Nature*, entitled, "Modern Views of Electricity," you will permit me to say that I should deeply regret to see any "older electricians who have accomplished work in the past having to retire to a back seat," and that for my own part I would much prefer to remain standing, than to assist in bringing about such an event.

But there are times when the stage is so high and the panorama so extensive, that a back seat is preferable to one too close in front for obtaining a comprehensive view. It is from a very back seat that I have described the action of a telegraph wire, and the mode in which it transmits signals, according to the best of my conception of the truth. Certainly the action is singularly complex, far less simple than the old useful idea of a tube full of water and a piston thrust, but the question is which is true.

It is no question of flight of fancy or luxuriance of imagination. It is a question of downright fact. Either the energy of the signal is transmitted by a thrust through the telegraph wire, or it is transmitted by the ether of the telegraph with a speed very near that of light, being simply guided by the wire to its destination.

Mr. Varley prefers the older view; and, if it were the true one, so would I. The real manner of transmission is no discovery of mine, I wish it were. But it seems to me that it has been discovered, and accordingly I state it as clearly as I can. If the statement is not true, if it does not accord in every particular with fact, by all means let it be overthrown.

Oliver J. Lodge.

September 1st, 1888.

Examination Questions.

Last year you published a letter in your columns which materially helped myself and other students of my acquaintance in preparing for the honours stage practical examination in electricity and magnetism. This year I have had success in attempting the examination, and as last year's practical questions formed a clue to at least one of this year's, I thought that for the benefit of future candidates under the Science and Art Department, it would be satisfactory to have a letter on the subject in the REVIEW.

The honours practical examination was dated for the 19th June, and lasted one day only. The instruments supplied were the very best, and in splendid working condition. No candidate had any excuse as regards the facilities for working out the questions, and every help

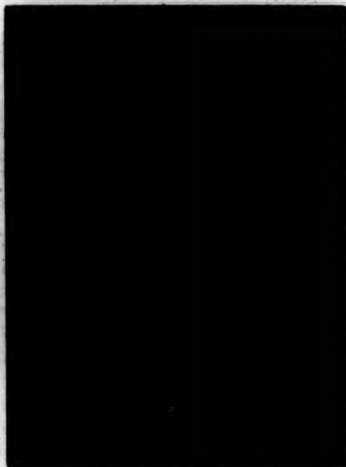
was given him to do well; the only curious thing was that no book of logarithms was allowed to shorten the long calculations occurring, especially in the first question. Three hours were allowed for the electricity questions in the morning, and the same time for the magnetism ones in the afternoon. The questions were such as anyone who has passed in the two junior stages, and has in the interval read up for this one, should have passed easily, both in the theoretical and practical examinations. The theoretical paper is easily obtained, and, no doubt, it will be published in these columns before long, so I refrain from giving it. The questions set for electrical testing were:—

I. "Measure the resistance of the wires supplied to you by means of the Post Office bridge. Determine the dimensions and the specific resistances of the material of which they are composed."

The wire was nearly 1 metre long, and about 36 B.W.G., and looked like new platinoid. Metre gauge and Elliott's ratchet gauge were supplied to make the mechanical measurements.

II. "Compare the resistances of two wires (coils of wire covered with brown paper and wound on wooden bobbins) by means of the ballistic galvanometer. For this purpose you are supplied with a condenser (1 microfarad mica, by Elliott), battery, galvanometer (Webb's discharge), key, and wires."

Connections for this test:—G, galvanometer; C, condenser; K, key; R_1 , first coil; R_2 , second coil; P_1 and P_2 , switches; R, reverser; B, battery; S, shunt.



TEST. II.

III. "You are given 10 Groves cells, a ballistic galvanometer and a shunt without self-induction, a condenser and a key. Observe the deflection produced by discharging the condenser through the galvanometer after it has been charged by each of the 10 cells in turn. Shunt the galvanometer to one-tenth and observe the deflection produced when the condenser has been charged by the 10 cells in series. The mean of the ten deflections obtained when the galvanometer was not shunted must be either greater, equal to, or less than the deflection obtained by using all 10 cells when it was shunted. Discuss, in view of the results of your experiments, the relation between them."

This is merely an easy point in theory and does not present any difficulty either in explanation or in practise.

In magnetism the following were given:—

"Compare the moments of the two magnets supplied to you by the two following methods:—

"(1) By means of the deflections they produce on a suspended magnet.

"(2) By comparing their times of vibration and determining their moments of inertia by weighing and measurements."

These are stock questions and fully dealt with in

every text-book. In conclusion, I may say that I had no requirement of higher mathematics, the examination being really an electrical one. Not having seen the REVIEW for some time I do not know if any other letter has appeared on this subject; at any rate, this is written without any bias and is just my own feeling about the examination.

Charles H. Yeaman.

London, N., September 1st.

High Insulation, No Earthing.

I read with great interest the article "High Tension Distribution" in the REVIEW of August 31st; I fully coincide with the views of the author with the exception of the two closing sentences, i.e.: "Of the plans for avoiding shocks from the secondary, it is difficult to see what valid objection can be raised to the simple one of earthing the secondary. This renders it impossible to get a shock from the secondary circuit under any conceivable circumstances, and we are at a loss to understand why it is not always resorted to."

The earthing of the secondary was, I think, first proposed by Prof. Thomson (Thomson-Houston Co., U.S.A.). His main purpose, however, was *not* the protection of human life, but to enable the engineer at the central lighting station to detect any short circuits between primary and secondary in transformers. If we can detect any such short circuits and remedy them *easily*, there would be no need of protecting human life against the alternating current of the secondary, which would not be above 110 volts.

The fact, however, remains that short circuits may occur between primary and secondary. If an earthing of the secondary is generally adopted, one of those short circuits on each pole will short circuit the dynamo—certainly a not very desirable result. For this reason alone the fire underwriters would hardly allow an earthing of the secondary.

Furthermore, it seems to me that we have just about succeeded in convincing the public how necessary it is to secure the highest possible insulation for our electric light leads, and now shall we suddenly turn a somersault and recommend earthing? This is driving out the Devil with Beelzebub. Earthing of one wire means putting on a permanent strain on the insulation of the wire of opposite polarity. A ground on one wire is like an outstretched hand grabbing for the weak points in the insulation of the other pole. Strangely enough, in the same number of the REVIEW containing the above mentioned article, I find "Rules issued to Contractors by the London Electric Supply Corporation" above the signature of S. Z. de Ferranti. Here I find that a *high insulation* resistance is demanded for house installations before the corporation will connect them to their high tension mains by means of transformers. Everybody with a little practical experience in incandescent wiring knows how easily a line is grounded in spite of all precautions. Permanently earthing one wire more than doubles the probability of getting more grounds.

These few reasons may suffice to-day, although this theme has not been exhausted by any means. Other ways must be found to protect human life and ensure at the same time safety to property against fire risks, and safety to the dynamo and machinery.

The main object must be to make a contact between the dangerous primary and the secondary almost impossible, but if this should occur an automatic detector at the central station should indicate it at once. The dangerous circuit may then be cut out.

Some companies in the United States put a well insulated metal shield between primary and secondary and earth this. Any contact of the primary with this shield can be very easily detected at the station, and the defective transformer replaced. This seems a good deal preferable to the earthing of the secondary. Human life must be protected, but so must property.

Transatlantic.

London, September 3rd, 1888.